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PROCESS OF TRANSFORMING HEAT

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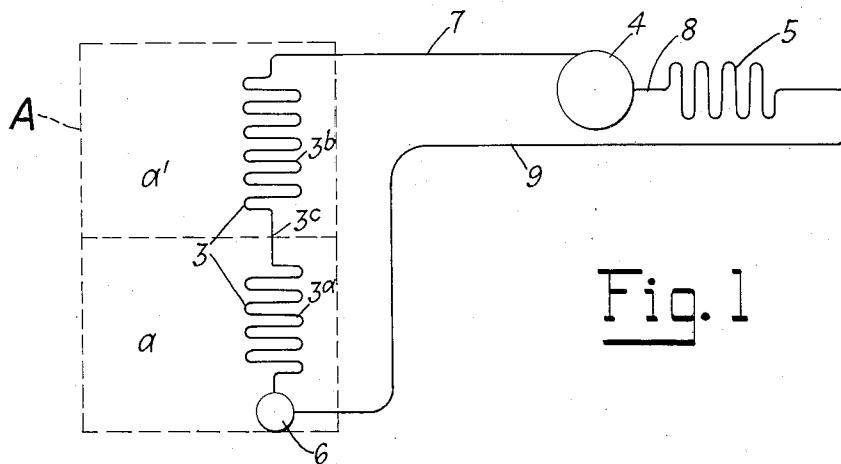


Fig. 1

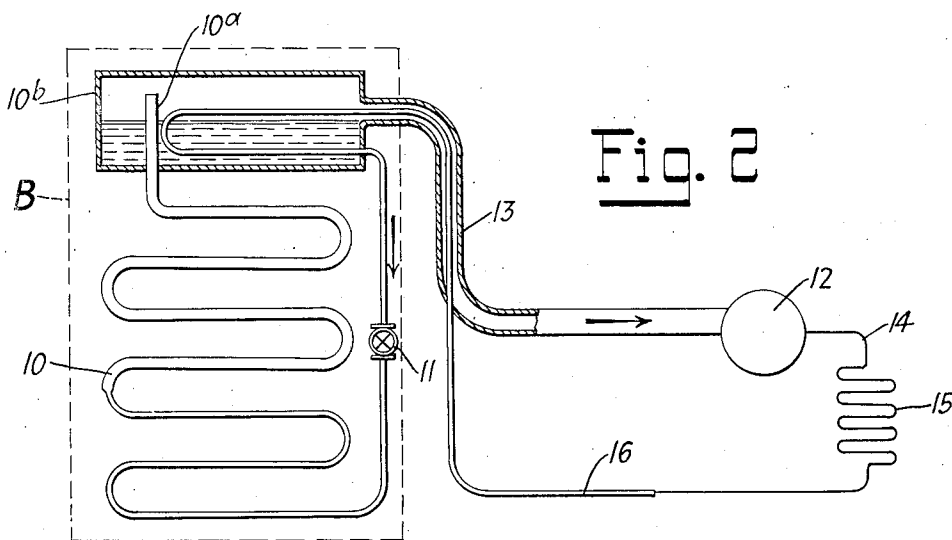


Fig. 2

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UNITED STATES PATENT OFFICE.

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PROCESS OF TRANSFORMING HEAT.

Application filed February 2, 1926. Serial No. 85,580.

This invention relates in general to processes of transforming heat and more specifically to the use of mixtures or solutions as working substances. It particularly relates to processes of producing refrigeration in which the working substance is a mixture of a refrigerant and a lubricant of the type disclosed and claimed in my copending application Serial No. 60,311, filed October 9, 1925.

One object of the invention is to devise processes of transforming heat by using as a working substance a mixture or a solution at least one component of which has heretofore been considered highly undesirable. Another object is to devise processes of utilizing lubricating refrigerants of the type described in my aforesaid copending application. Other objects will be apparent from the detailed description which follows:

Heretofore it has been considered highly detrimental in practicing the conventional methods of transforming heat for foreign matter such as lubricant, particularly when the latter is soluble in the working substance, to become mixed with the latter. It is an inevitable tendency of nature to cause the lubricant to collect and segregate in the lower temperature part of the system, not alone because the lubricant is atomized or mechanically carried along with the vapor from the compressor, through the condenser, into the refrigerator, but also because all lubricants have a finite vapor tension, even if it be relatively low, and this vapor must inevitably find its way eventually into the colder parts where it accumulates. "Separators" commonly used in a variety of forms, to reduce the former effects are futile to check the latter.

These effects are cumulative, and all such artifices as are at present known in the art merely delay the time when either the lubricant has collected in the refrigerating member in sufficient quantity to reduce the vapor tension of the refrigerant and to impede heat transfer at its inner surfaces, or the lubricant in the compressing member has become depleted and diluted to a point where its effectiveness is lost.

If an insoluble substance of indifferent lubricating value like glycerine is chosen as the lesser of two evils, as is now common practice when hydro-carbon vapors are compressed, the vapor tension of the refrigerant

remains unimpaired and also the viscosity of the glycerine; but unfortunately the very fact that it is insoluble prevents the refrigerant from properly wetting the metal surfaces from which it is supposed to take in heat, when these surfaces become coated with the lubricant as they eventually must.

In practicing my improved process the working substance is modified as desired in order that it may be utilized to perform work additional to that of transforming heat; as for example to lubricate the moving parts of apparatus necessary to the operation of the process. To this end a suitable working substance or refrigerant may have mixed therewith or in solution a certain definite amount of a suitable lubricant as set forth in my aforesaid copending application. The basic principle of the operation of my process may then be stated as the fractional distillation of the fluid mixture and the utilization of the less volatile fractions for lubrication followed by the dilution of the less volatile fractions after they have performed their functions as a lubricant by the condensate of the more volatile fractions at a higher temperature and pressure, followed by the vaporization of the more volatile fractions of the solution and the repetition of these steps in a continuous closed cycle.

In order that the concentration of the lubricant may be carried to the required extent to secure adequate lubrication of the working parts, it is necessary that the mixture or solution while still in the low pressure part of the system be subjected to a relatively high temperature for a sufficient period or to progressively higher temperatures so that the more volatile fractions may escape as vapor. This result may be secured by the application of heat from an external source, or by moving the liquid through refrigerating zones of progressively higher temperatures from the coldest to the warmest so that it leaves the refrigerator at approximately the highest temperature in accordance with the vapor-gas principle disclosed in my copending applications, Serial No. 708,936, filed April 25, 1924, now Patent No. 1,619,195, reissued as No. 17,078, and Serial No. 77,156, filed December 22nd, 1925, now Patent No. 1,680,453, or by raising its temperature still higher by directing it counter-current through an interchanger in which it is warmed while cool-

ing the diluted liquid or solution from the condenser.

The invention and the manner of its operation may be best explained with reference to the accompanying drawings, in which

Fig. 1 is a diagrammatic illustration of a very simple form of apparatus for practicing the invention; and

Fig. 2 illustrates a preferred arrangement with certain of the apparatus shown in detail.

While the invention relates to heat engines in general it will be described in its application to refrigeration. As illustrated in Fig. 1 the essential apparatus consists of an evaporator 3 which may be disposed within a structure from which heat is to be extracted such as a refrigerator A indicated in dotted outline, a pump 4, a condenser 5 and a feeding device 6. The elements may be of any suitable or desired type. Suitable connections or conduits as indicated at 7, 8 and 9 connect said elements to form a closed cycle. The system is charged with a suitable working substance, such as a liquid comprising a mixture or solution of a refrigerant and a suitable amount of lubricant. One mixture or solution which may be used consists of the following components in substantially the proportion indicated

	Per cent.
Methylene chloride-----	85
Grease -----	15

The invention consists in so directing and controlling the working substance that it will perform the dual function of heat transforming and of lubricating the apparatus necessary for the operation of the system. To accomplish these objects the liquid working substance is circulated through the system with periodical variations in the composition of the liquid so that at one point the relatively non-volatile components thereof, such as the grease, predominate and are in a highly concentrated form so as to act as a lubricant, and at another point the volatile components predominate so as to serve efficiently as a refrigerant. Briefly described the process consists in causing evaporation of the liquid working substance in evaporator 3, raising the temperature of the evaporating fluid so as to produce further evaporation and a greater concentration of the lubricant, moving the concentrated lubricant into pump 4 and utilizing it to lubricate the moving parts thereof, forcing the concentrated lubricant along with the vapor of the refrigerant into condenser 5, diluting the concentrated lubricant with the condensed refrigerant and moving the cool dilute working substance (now substantially in its original

state) to the feeding device 6 and thence into the evaporator 3. To produce vaporization of the lubricating refrigerant to such an extent as to concentrate it sufficiently for lubricating purposes provision is made for progressively raising the temperature of the lubricating refrigerant from the time vaporization begins until the moving fluid reaches pump 4. To this end evaporator 3 may be in two parts 3^a and 3^b disposed in chambers *a* and *a'* of the refrigerator A and having a connection 3^c therebetween so restricted that back flow of the refrigerating fluid is prevented. Compartment *a* is maintained at a lower temperature than compartment *a'* so that the moving lubricating refrigerant tends to leave part 3^b of the evaporator at a higher temperature than it leaves part 3^a. After the lubricating refrigerant leaves the zone of refrigeration and enters connection 7 heat is applied to the same in some manner (not shown) either from the system or from an external source to produce further vaporization of the refrigerant and a still greater concentration of the lubricant. Thus by the time the fluid reaches pump 4 the more volatile portions of the same have been largely driven off in the form of vapor and the lubricant is highly concentrated. Pump 4 may be of either the rotary or the reciprocating piston type and the concentrated lubricant is arranged to be conducted to the moving parts thereof which require lubrication. In a reciprocating piston pump the concentrated lubricant may enter the crank case and be pumped thence into the cylinder or may enter first the cylinder and be pumped thence into the crank case. From the compressor 4 the vapor and concentrated lubricant is forced at an increased pressure through connection 8 into condenser 5 where it gives up its heat and the vapor becomes condensed to liquid form and dilutes the concentrated lubricant. The cool, dilute lubricant or working substance in substantially its original state then passes through connection 9 to feeding device 6 and thence into evaporator 3^a, thus completing the cycle.

Fig. 2 discloses in greater detail suitable apparatus by which a high concentration of the lubricant component of the working substance may be secured without the application of external heat. In this arrangement progressively higher temperatures of the evaporating working substance are obtained in the evaporator 10 in refrigerating chamber B by using apparatus which operates in accordance with the process disclosed in my aforesaid copending application Ser. No. 77,156, filed December 22, 1925. In accordance with the said process the working substance includes not only the liquid solution specified in relation to Fig. 1, but also

a gas inert to and substantially insoluble in the solution, a feeding device 11, which may take the form of a Venturi nozzle adapted to pass both the gaseous and the liquid components of the working substance in contiguity, and an evaporator 10 having an elongate passage therethrough so restricted in size as to greatly retard, if it does not entirely prevent back flow of liquid toward the feeding device 11. By interfering with the back flow of the fluid in evaporator 10 as described in my aforesaid copending application Serial No. 77,156 the expanding and vaporizing of the working substance produced by the combined action of compressor 12 and restricted feeding device 11 causes absorption of heat by the liquid in the evaporator 10 at progressively higher temperatures as the top of the evaporator is approached. The top of the evaporator is preferably formed with a chamber or header 10^b which serves as a reservoir for the concentrating lubricant which spills or overflows from pipe 10^a which terminates near the top of the header 10^b. Pipe 13 which leads to compressor 12 issues from header 10^b intermediate the top and bottom of the same but below the open end of pipe 10^a. Thus a considerable amount of concentrating lubricating refrigerant can remain in the header 10^b with a tendency to approach in temperature that of the warmest part of refrigerating chamber B. The lubricating refrigerant in the header accordingly becomes more concentrated and is gradually drawn off with the vapor of the refrigerant into pipe 13. During its transit through pipe 13 heat is supplied so as to drive off more of the volatile components of the fluid and to produce a higher concentration of the lubricant in a manner presently to be described. In compressor 12 the concentrate is utilized for lubrication and is then forced along with the mingled vapor and gas at a higher pressure through connection 14 into condenser 15 where the concentrated lubricant is diluted by the condensation of the vapor and the relatively warm dilute fluid with the accompanying gas vapor is conducted by pipe 16 within and along pipe 13 to form a heat exchanger and into chamber 10^b, as indicated, with the result that the concentrate in chamber 10^b and pipe 13 is further concentrated at the expense of heat from the products of condenser 15, which products accordingly reach feeding device 11 in a precooled condition. Compressor 12 may, like compressor 4 of Fig. 1, be of any suitable or desired type and the process which is the law of operation of the apparatus shown in Fig. 2 is in its essentials that of the process described in relation to Fig. 1.

The steps of the preferred process as illustrated by Fig. 2 may be set forth in full detail as follows:

1st. Evaporating a body of lubricating refrigerant in the zone of lower temperature refrigeration and increasing the concentration of the lubricant while producing refrigeration.

2nd. Moving a portion of the lubricating refrigerant to a zone of intermediate refrigerant temperatures and then evaporating it to further increase the concentration of lubricant while producing refrigeration.

3rd. Moving said portion of lubricating refrigerant into a heat exchanger and then evaporating it to still further increase concentration of lubricant at the expense of heat from the liquid supplied to the interchanger from the condenser.

4th. Moving said concentrated portion to the compressor and conducting it to the parts requiring lubrication.

5th. Discharging said concentrated lubricant and the vaporized refrigerant into the condenser and diluting the lubricant with the condensed vapor of the refrigerant.

6th. Moving the diluted lubricating refrigerant into the interchanger and cooling it by thermal contact with the aforesaid concentrated lubricating refrigerant.

7th. Moving the cool, dilute lubricating refrigerant to the feeding device and lowering the pressure thereof.

8th. Moving the lubricating refrigerant back into the evaporator and repeating the process.

From the above it will be apparent that the herein disclosed process of transforming heat by the use of lubricating refrigerants secures improved lubrication of the moving parts of apparatus necessary to the practicing of the process by virtue of the substantially unrestricted choice of lubricants to secure the required physical and chemical properties, and that more efficient operation of heat engines is secured by eliminating the clogging up and blocking of the system with lubricants foreign to or insoluble in the refrigerant.

I claim as my invention:

1. The process of transforming heat with a working substance having lubricant mixed therewith which comprises evaporating a body of the lubricating working substance to absorb heat and to produce concentration of the lubricant, moving the concentrated working substance from the heat absorbing zone and subjecting it to heat to still further increase the concentration of lubricant, compressing the vapor and concentrated lubricant to a higher total pressure, diluting the concentrated lubricant by condensing the vaporized portion of the working substance, again vaporizing the diluted mixture, and continuously repeating the aforesaid operations.

2. The process of transforming heat in accordance with the vapor-gas principle

with a working substance having lubricant in solution which comprises evaporating a body of the lubricating working substance to absorb heat and to produce concentration of the lubricant, moving the concentrated working substance through the heat absorbing zone and progressively raising its temperature so as to still further increase the concentration of lubricant, compressing the vapor and concentrated lubricant to a higher total pressure, diluting the concentrated lubricant by condensing the vaporized portion of the working substance, again vaporizing the diluted mixture, and continuously repeating the aforesaid operations.

3. The process of transforming heat with a working substance having lubricant mixed therewith which comprises evaporating a body of the lubricating working substance to absorb heat and to produce concentration of the lubricant, moving the concentrated working substance through the heat absorbing zone and gradually raising its temperature so as to still further increase the concentration of the lubricant, moving the concentrated working substance from the heat absorbing zone and subjecting it to heat to still further increase the concentration of lubricant, compressing the vapor and concentrated lubricant to a higher total pressure, diluting the concentrated lubricant by condensing the vaporized portion of the working substance, again vaporizing the diluted mixture, and continuously repeating the aforesaid operations.

4. The process of transforming heat with a working substance having lubricant mixed therewith comprising moving a body of the working substance through a closed cycle, producing evaporation of the more volatile part of the working substance at progressively higher temperatures so as to concentrate the lubricant, applying heat to the concentrated mixture still further to evaporate and concentrate the same, compressing the vapor and concentrated lubricant to a higher total pressure, diluting the concentrated lubricant by condensing the vaporized portion of the working substance, again vaporizing the diluted mixture, and continuously repeating the aforesaid operations.

5. The process of transforming heat with a working substance having lubricant mixed therewith comprising moving a body of the working substance through a closed cycle, producing evaporation of the more volatile part of the working substance at progressively higher temperatures so as to concentrate the lubricant, applying heat to this concentrated mixture still further to evaporate and concentrate the same, compressing the vapor and concentrated lubricant and diluting the latter by condensing the vaporized portion of the working substance, again

vaporizing the diluted mixture, and continuously repeating the aforesaid operations.

6. In a closed cycle system of the evaporating-compressor-condenser type operating on the vapor-gas principle the process of producing refrigeration which comprises utilizing as a working substance a solution of a volatile refrigerant and of a relatively non-volatile lubricant, passing a body of the working substance continuously through the system while vaporizing it at progressively higher temperatures on the low pressure side to concentrate the lubricant whereby the concentrate may be utilized to lubricate the compressor, and condensing the volatilized refrigerant to dilute the concentrated lubricant in the high pressure side of the system whereby the solution may be again available for absorbing heat in the evaporator.

7. In a closed cycle system operating on the vapor-gas principle and using as a working substance a solution of lubricant in a vaporizable liquid the process of producing refrigeration which comprises circulating the working substance through the system and alternately concentrating and diluting the lubricant component so that the working substance may perform the dual functions of lubrication and heat transforming, concentration of the working substance being effected by progressively raising its temperature in the zone of refrigeration so as to effect fractional separation of its components.

8. In a closed cycle system operating on the vapor-gas principle and using as a working substance a solution of lubricant in a vaporizable liquid and producing refrigeration through a process which involves circulating the working substance through the system, that step in the process which comprises effecting an interchange of heat at one point between the concentrating and the diluting streams of the working substance whereby heat absorbed in the first named stream makes it still more concentrate while the heat removed from the second named stream makes it more dilute due to the evaporating and the condensing respectively of the more volatile component of the working substance.

9. In a closed cycle system operating on the vapor-gas principle and utilizing as a working substance a fluid mixture having components of relatively high and low volatility in solution, the process of producing refrigeration which comprises subjecting the working substance to fractional distillation at a plurality of refrigerating temperatures, utilizing the less volatile fractions for lubrication, diluting the less volatile fractions at higher temperatures by mingling therewith the condensate of the more volatile fractions, so as to restore the working substance to substantially its original condition, and re-

peating the said steps in a continuous closed cycle.

10. In a closed cycle system of the evaporator-compressor-condenser type utilizing a working substance which includes a liquid refrigerant having lubricant in solution the process of refrigeration which comprises evaporating a body of the lubricating refrigerant in the zone of lower temperature refrigeration and increasing the concentration of the lubricant while producing refrigeration, moving a portion of the lubricating refrigerant to a zone of intermediate refrigerating temperatures and evaporating it further to increase the concentration of lubricant while producing refrigeration, moving said portion of lubricating refrigerant into a zone of heat exchange with the stream discharged from the condenser still further to increase the concentration of lubricant, moving said concentrated portion of lubricant into the compressor and utilizing it for lubrication, discharging said concentrated lubricant into the condenser and diluting it with condensed vapor of the refrigerant, moving said diluted lubricating

refrigerant into the zone of heat exchange to give up its heat by thermal contact with the stream of concentrating refrigerant, feeding the cool dilute lubricating refrigerant into the evaporator and lowering the pressure thereon, and continuously repeating the above steps.

11. In a closed cycle refrigerating system operating on the vapor-gas principle and using as a working substance a solution of a lubricant in an evaporable liquid, that step in the thermal process which comprises reducing the pressure on the solution and applying heat to cause the volatile component to evaporate, thereby to concentrate the solution while absorbing heat, and continuing the concentrating of the solution by progressively raising the temperature thereof while still in the low-pressure zone so as to effect fractional separation of the components of the solution, whereby the volatile component is available for refrigeration and the concentrate for lubrication.

Signed by me at Detroit, Wayne County, Michigan, this 25th day of January, 1926.

RANSOM W. DAVENPORT.