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REFRIGERATION SYSTEM EMPLOYING HEAT ACTUATED COMPRESSOR

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Fig. 1

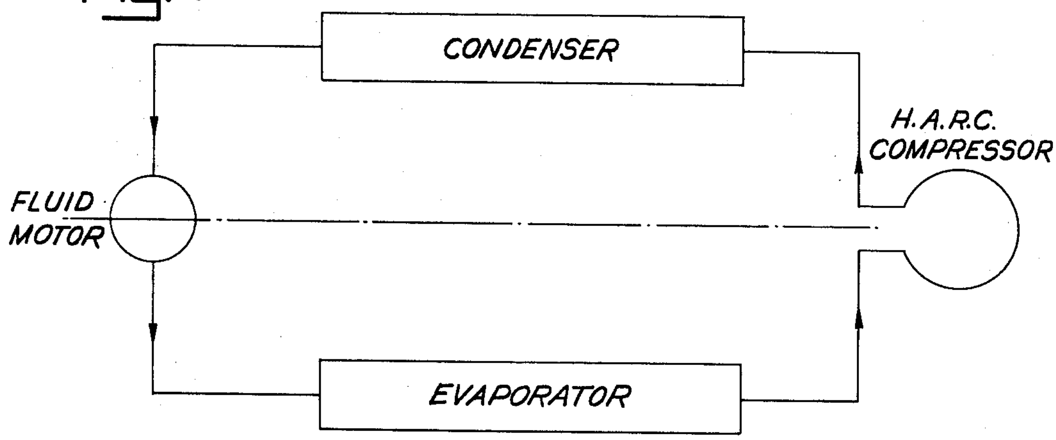
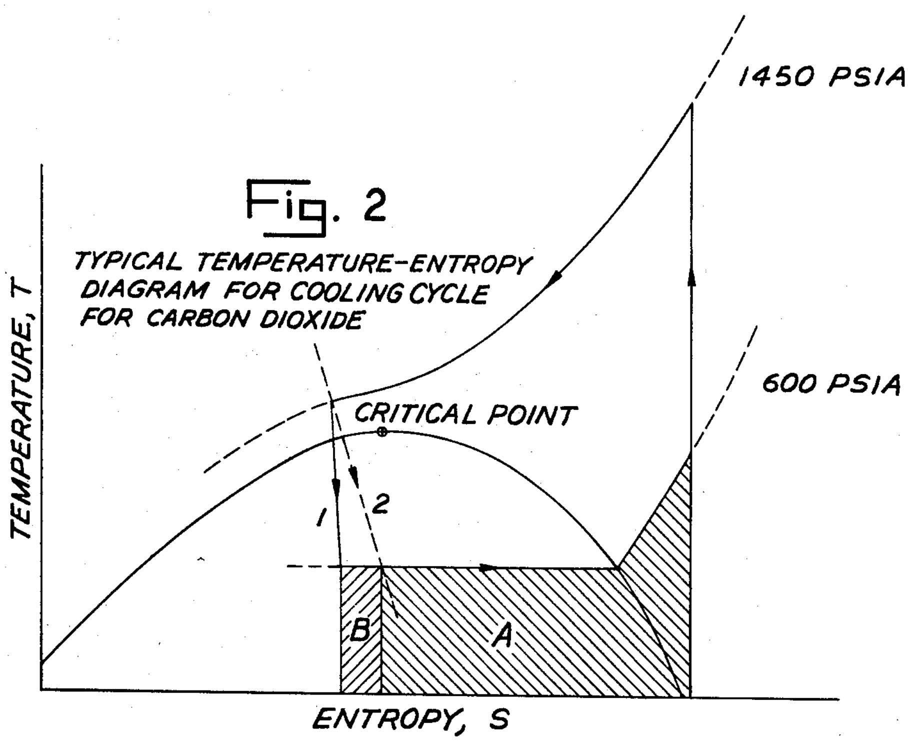


Fig. 2

TYPICAL TEMPERATURE-ENTROPY DIAGRAM FOR COOLING CYCLE FOR CARBON DIOXIDE



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REFRIGERATION SYSTEM EMPLOYING HEAT ACTUATED COMPRESSOR

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3 Claims. (Cl. 62—498)

ABSTRACT OF THE DISCLOSURE

A closed cooling system. The system includes a conduit and a cooling medium of carbon dioxide or sulfur dioxide. An evaporator is connected to the conduit and operates at a relatively low pressure. A heat actuated compressor increases the pressure of the cooling medium passing from the evaporator at a relatively low pressure to a relatively high pressure. A condenser is connected to receive the cooling medium passing from the compressor. The cooling medium passes from the condenser in a high pressure, condensed condition. A fluid operated motor is connected to the conduit between the condenser and the evaporator and the fluid motor is mechanically operated by the flow of the condensed fluid passing through the motor from the condenser to the evaporator. The flow of the cooling medium through the fluid motor provides useful mechanical energy for the fluid motor and the cooling capacity of the system is increased.

This invention relates to a novel improvement in air-conditioning and refrigeration systems and, in particular, to an improved air-conditioning system with a heat-actuated compressor.

Typical air-conditioning and refrigeration systems comprise four basic elements: A compressor for taking a gas at a first relatively low pressure and compressing it to a second relatively high pressure; a condenser, normally water or air-cooled, for cooling and liquefying the compressed gas to remove the latent heat of evaporization; a throttle valve through which the liquefied gas is expanded into a zone of relatively low pressure; and an evaporator in which the expanded gas absorbs its latent heat of vaporization from the surroundings to be cooled.

Air-conditioning and refrigeration cycles for systems using gases such as carbon dioxide as refrigerant have low thermodynamic efficiency because the state of the refrigerant in the condenser is supercritical. Expansion of refrigerant such as carbon dioxide through a throttle valve results in wasteful loss of cooling capacity of the system due to unfavorable temperature-entropy considerations, more fully discussed hereinafter.

The object of this invention is to provide a modified and improved cycle for an air-conditioning or refrigeration system with a heat-actuated compressor wherein the cooling capacity of the system is increased, while at the same time useful mechanical work is obtained from the system.

In the drawings:

FIG. 1 is a diagrammatic view showing an air-conditioning or refrigeration system according to the invention; and

FIG. 2 is a temperature-entropy diagram for carbon dioxide illustrating the advantages of my system.

My invention comprises using a fluid-actuated motor to control the flow of fluid carbon dioxide between the condenser of the cooling system and the evaporator rather than using a throttling valve as is conventional practice. Considerable improvement is the performance of a carbon dioxide air-conditioning or refrigeration system can be achieved by the arrangement of my invention which is shown diagrammatically in FIG. 1 wherein a fluid motor is placed between the high-pressure source (condenser) and the low-pressure source (evaporator) in an air-conditioning or refrigeration system and is driven by fluid passing from the condenser to the evaporator.

The fluid motor may be any type of motor well known in the art capable of being driven by a pressurized fluid flowing from a region of high-pressure source to a region of low-pressure.

The use of a fluid motor as above described is particularly advantageous in a system employing carbon dioxide as refrigerant while systems using other refrigerants, such as SO_2 provide only a small mechanical output due to temperature-entropy considerations. In addition, my system has distinct advantages over an air cycle-conditioning system in which a turbine is arranged similarly to the fluid motor of my system. In the air cycle scheme, the system is an open system using air as the working fluid, the air being in gaseous state throughout the cycle, whereas in my system, the refrigerant is liquefied or rendered supercritical while circulating through the condenser of the system.

Use of CO_2 as refrigerant in conjunction with a heat-actuated regenerative compressor, as described in my co-pending application Ser. No. 547,040 filed May 2, 1966, results in a mechanical output from the fluid motor of about 1 H.P. in a 3-ton air-conditioning system, assuming motor efficiency to be 70%. In addition, the co-efficient of performance of the cooling cycle simultaneously is improved about 7%. My system using carbon dioxide as refrigerant can be made completely self-sufficient, i.e. the work done by the fluid motor is sufficient to satisfy the mechanical energy requirements of the heat-actuated regenerative compressor as well as the necessary fans in the system.

The mechanical output of the fluid motor per ton of refrigeration can be varied over wide limits depending on temperatures and pressures in the system. For example, as one limit, if no heat exchange takes place in the condenser, the system is converted to a power generation system.

The reason for the advantages of the system of my invention can best be seen by referring to FIG. 2 which is a temperature-entropy diagram for carbon dioxide. Assuming a cooling system in which the condenser operates at 1450 p.s.i.a. and the evaporator at 600 p.s.i.a., line **2** of FIG. 2 illustrates the entropy change of a system using a throttling valve when the fluid carbon dioxide at 1450 p.s.i.a. in the condenser is throttled down to 600 p.s.i.a. in the evaporator. The slope of line **2** shows the relatively large increase in entropy associated with the irreversible throttling process.

On the other hand, line **1** shows the entropy change associated with use of the fluid motor arrangement of my invention. Note that the entropy change is small as compared to the throttling process.

The total area A plus B in FIG. 2 represents the cooling capacity of the system using the fluid motor arrangement of my invention. Area B represents the equivalent of the mechanical output of the fluid motor and also the improvement in cooling capacity using the motor compared to the capacity of a system using a throttling valve instead of the fluid motor. As can be seen from FIG. 2, the system of my invention provides not only for increased cooling capacity but in addition for available mechanical work for use in auxiliary parts of the overall cooling system, such as for running fans or operating the compressor as above noted.

By using the system of my invention, it is possible to vary the temperature to which the highly compressed CO_2 is cooled in the condenser, and in this way vary the ratio of mechanical work and cooling effect which can be gotten from the compressed fluid by use of the fluid motor and the evaporator. For example, as noted above, if no heat exchange takes place in the condenser, the system is operated as a power-generator system. Alternatively, the compressed fluid can be cooled to varying degrees in the condenser and the system correspondingly operates as a combined cooling system and power generation system.

Those skilled in the art will recognize that various modifications can be made to the principle of my invention within the scope thereof which I intend to be limited solely by the following claims.

I claim:

1. A closed cooling system comprising conduit means, a cooling medium selected from the group consisting of carbon dioxide and sulfur dioxide and passing through said conduit means, an evaporator connected to said conduit means, and being operated at a relatively low pressure, a heat actuated compressor connected in said conduit means for increasing the pressure of the cooling medium passing from said evaporator at a relatively low pressure to a relatively high pressure, a condenser connected to said conduit means and being operated at a relatively high pressure, said cooling medium passing from said compressor to said condenser and passing from said condenser in a relatively high pressure and condensed condition, and a fluid operated motor connected to said conduit means between said condenser and said evaporator, said fluid motor being mechanically operated by the flow of said relatively high pressure condensed cooling medium passing therethrough from said condenser to said evaporator, the flow of said cooling medium through said fluid motor providing useful mechanical energy for said fluid motor and the cooling capacity of said system is increased.

2. The system of claim 1 wherein said compressor is a heat actuated regenerative compressor and said fluid motor is operatively connected to said heat actuated regenerative compressor to provide mechanical energy for the operation thereof.

3. The system of claim 2 wherein said cooling medium is carbon dioxide.

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