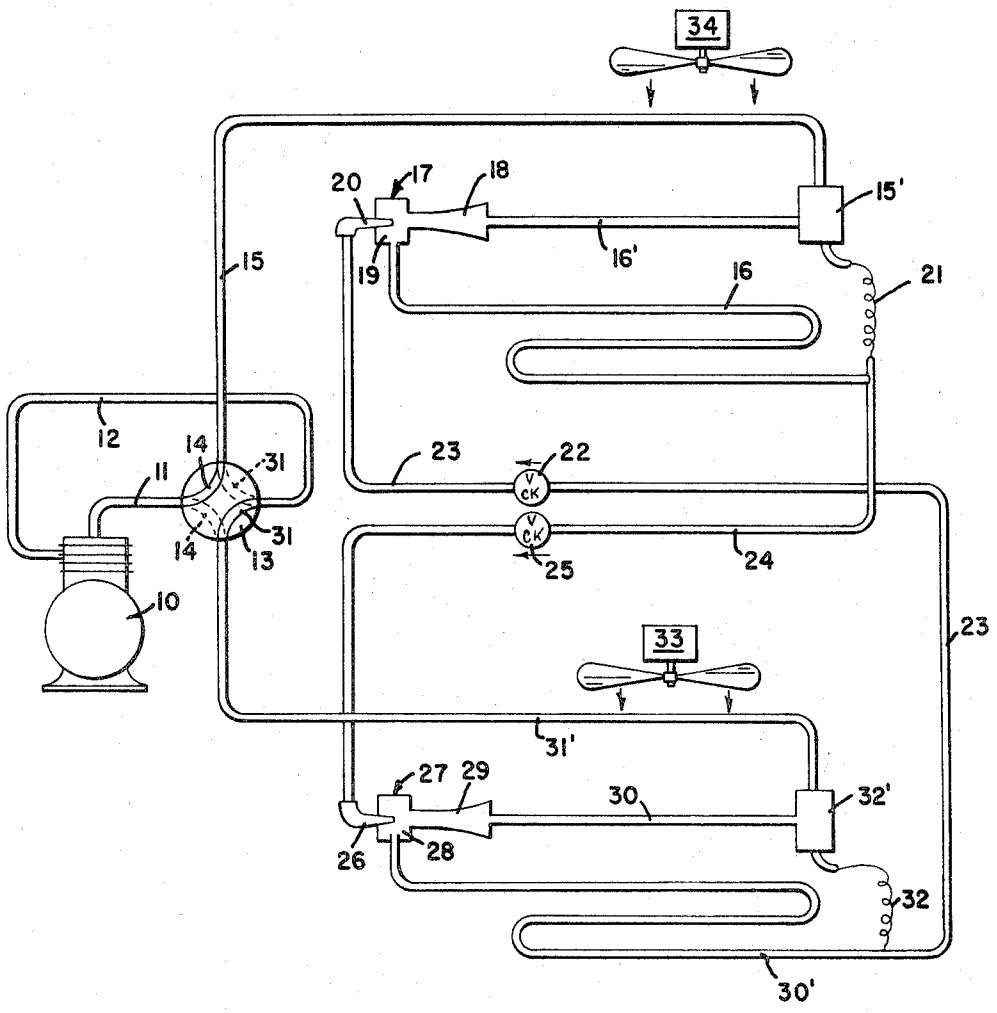
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REVERSE CYCLE REFRIGERATION SYSTEM

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INVENTOR.
WILLIAM L. MC GRATH.
BY Raymond Curtin
ATTORNEY.

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REVERSE CYCLE REFRIGERATION SYSTEM

William L. McGrath, Syracuse, N.Y., assignor to Carrier Corporation, Syracuse, N.Y., a corporation of Delaware

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This invention relates generally to heat pumps of the kind employed for heating and cooling air in an air conditioning plant, more particularly, this invention relates to a novel refrigeration circuit operable under the reverse cycle principle for use with heat pumps of the kind described.

It is well known that the coupling of mechanical compressors of a refrigeration system in a series relationship will produce lower evaporator temperatures or increased capacity at a particular evaporator temperature. It has also been proposed to couple mechanical compressors in a series relationship when a refrigeration system is being used on the reverse cycle for heating in order to produce increased heating capacity. However, since mechanical compressors are costly, any increased capacity which is obtainable by their staging is more than off-set by the high cost involved. It is therefore with the overcoming of the foregoing shortcomings of the prior art while retaining the benefits thereof that the present invention is concerned.

It is therefore the chief object of the present invention to provide a reversible heat pump which will produce staged compression in a simple, efficient and economical manner on both the cooling and heating cycles without the use of an additional mechanical compressor.

It is another object of this invention to provide a heat pump wherein the benefits of staged compression may be obtained by utilizing energy in the cycle which is normally considered as waste energy. In attaining this object, it is proposed that energy available in the flow of refrigerant may be utilized to create pressure differences within the system of the kind normally obtained by connecting two mechanical compressors in series. With the arrangement of parts contemplated, relatively inexpensive pumping mechanisms such as ejectors may be employed in order to create the system flexibility normally achieved with staged mechanical compressors.

An additional object of the invention is the provision of means associated with said ejectors for separating refrigerant flow emanating from the ejectors so that the liquid portion thereof is circulated through the evaporator and the vapor portion thereof is transmitted to the compressor. Thus, the ejector will create a lower pressure in the evaporator than exists in the suction line receiving refrigerant flow for passage to the compressor.

The present invention relates to a staged heat pump operable to selectively provide heating or cooling, comprising a compressor, a first heat exchange coil normally adapted to function as a condenser adapted to be coupled to the discharge side of said compressor, a second heat exchange coil normally adapted to function as an evaporator adapted to be coupled to the suction side of said compressor, expansion means effectively interposed between said first and second heat exchange coils, reversing valve means coupled between said coils and said compressor for interchanging the functions of said first and second coils, and ejector means operatively associated with both said first and second coils for producing staged compression on both the heating and cooling cycles.

The present invention will be more fully understood when the following portions of the specification are read in conjunction with the accompanying drawing which schematically illustrates a preferred embodiment of the invention.

In the drawing a mechanical compressor 10 is shown

having a discharge line 11 and a suction line 12. These lines are connected to a four-way valve 13 which operates in the conventional manner. Passageway 14 of valve 13 is adapted to couple discharge line 11 to conduit 15 which leads to refrigerant collecting vessel 15' which in turn is coupled by conduit 16' to ejector 17 which is connected to outdoor coil 16.

When valve 13 is in the position shown in the drawings, the refrigeration system is on the cooling cycle and outdoor coil 16 functions as a condenser. The ejector 17 includes a diffusion chamber 18, suction chamber 19 and a nozzle 20. When coil 16 functions as a condenser, refrigerant flows from conduit 15 to collecting vessel 15' and conduit 16' into diffusion chamber 18, then into suction chamber 19 from which it flows to condenser coil 16. It is to be noted that an expansion member such as capillary 21 is provided between vessel 15' and the end of condenser portion 16 which is remote from suction chamber 19. A check valve 22 is provided in conduit 23 which has one end connected to nozzle 20. As can be seen, the check valve 22 and the resistance to flow offered by capillary 21 causes refrigerant flow to be through condenser portion 16, as described above.

Condensed refrigerant therefore flows from coil 16 through conduit 24 and check valve 25 to the nozzle 26 of ejector 27. The refrigerant then passes at high velocity through suction chamber 28 of ejector 27, and then through diffuser portion 29 where its pressure is increased above the pressure that would normally be present at this point due to the suction of compressor 10. The refrigerant then passes into one end of conduit 30. The other end of conduit 30 is connected to collecting vessel 32' which is in turn connected by conduit 31' to passageway 31 of reversing valve 13. The indoor heat exchange coil 30' has one end which communicates with suction chamber 28 of ejector 27. The other end of coil 30' communicates the collecting vessel 32' through an expansion member 32 which may be a capillary, as shown.

The high velocity passage of refrigerant produced by nozzle 26 of ejector 27 causes a lower suction to be created in suction chamber 28. This will cause a portion of the refrigerant in collecting vessel 32' to pass through capillary 32 where it is expanded and then through indoor coil section 30' from which it is induced into suction chamber 28 and is accelerated by the refrigerant being projected from nozzle 26. Coil section 30' thus functions as an evaporator. The mixture of refrigerant being projected from nozzle 26 with the refrigerant being sucked into suction chamber 28 from coil section 30' passes into diffuser 29 where the pressure of the refrigerant mixture is increased. This mixture then passes through conduit 30, and the gaseous portion of the mixture passes through vessel 32', conduit 31', passageway 31 of valve 13, and into suction line 12 of compressor 10. The ejector 27, operating in the foregoing manner, produces a compression which causes the suction pressure of compressor 10 to be increased. This increased suction pressure in compressor 10 causes a corresponding lower suction temperature in indoor coil section 30', thus providing increased refrigeration capacity.

The foregoing has described the operation of the refrigeration system on the cooling cycle. If it is desired to place the refrigeration system on the heating cycle, valve 13 is manipulated so that passageways 14 and 31 assume the dotted line positions. As can be seen from the drawing, indoor coil 30' will now function as a condenser and outdoor coil 16 now functions as an evaporator. Under these circumstances, the functions of ejectors 27 and 17 are now reversed so that ejector 27 merely acts as a conduit for refrigerant, while ejector 17 produces compression.

In operation on the heating cycle, refrigerant flow is from compressor **10** through discharge line **11** and conduit **14** (dotted line position) into conduit **31'**. The refrigerant flows from conduit **31'** into vessel **32'**, then through conduit **30** into diffuser portion **29** and suction chamber **28**, from which it flows into coil section **30'**. The one-way valve **25** prevents refrigerant from passing into conduit **24** and the capillary restrictor **32** prevents refrigerant from bypassing coil section **30'**. The condensed refrigerant therefore flows through conduit **23** including check valve **22** into the nozzle portion **20** of ejector **17**. The high velocity discharge of refrigerant from nozzle **20** creates a suction in suction chamber **19** and thus induces refrigerant from collecting vessel **15'** through expansion member **21** and through evaporator **16**. The refrigerant coming from coil **16** is mixed with the refrigerant projected from nozzle **20** and passed to diffuser **18** where the pressure of the refrigerant is increased. The refrigerant then passes through conduit **16'**, vessel **15'**, and conduit **15** to passageway **31** (which is now in the dotted line position), and then through suction line **12** to compressor **10**.

As described previously relative to ejector **27**, ejector **17** thus produces a stage of compression which in turn increases the suction pressure of compressor **10**. This increased suction pressure is accompanied by a lower suction temperature within coil **16** which in turn increases the capacity of the system on the heating cycle.

An indoor coil fan **33** and an outdoor coil fan **34** are provided for passing air over their respective coils in the direction of the arrows. It can readily be seen that, regardless of whether the outdoor and indoor coils are functioning as condensers or evaporators, the air flowing across these coils is always in a counterflow relationship.

It can thus be seen that I have provided a reversible heat pump which is operable on both the heating and cooling cycles to produce staged compression in a simple, efficient and economical manner without the use of an additional mechanical compressor.

While I have described a preferred embodiment of my invention, I desire it to be understood that it may be otherwise embodied within the scope of the following claims.

I claim:

1. A heat pump operable to selectively provide heating or cooling comprising a compressor, a first heat exchange coil adapted to function as a condenser normally coupled to the discharge side of said compressor, a second heat exchange coil adapted to function as an evaporator normally coupled to the suction side of said compressor, expansion means effectively interposed between said first and second heat exchange coils, reversing valve means coupled between said coils and said compressor for interchanging the functions of said first and second coils, said expansion means including ejector means and flow restriction means operatively associated with both said first and second coils, said ejector means decreasing the pressure in the coil functioning as an evaporator and increasing the pressure of the refrigerant supplied to said compressor.

2. A heat pump as set forth in claim **1** wherein said ejector means comprises a first ejector associated with said first coil and a second ejector associated with said second coil, each of said ejectors decreasing the pressure in the evaporator and increasing the pressure of the refrigerant supplied to said compressor only when the coil associated therewith functions as an evaporator.

3. A heat pump as set forth in claim **2** wherein each of said ejectors comprises a nozzle, a suction chamber, and an outlet portion, the nozzle of either ejector, when in operation being coupled with the coil functioning as a condenser, said outlet portion being in communication with the suction side of said compressor, and said suction chamber being in communication with the coil functioning as an evaporator.

4. A heat pump as set forth in claim **3** including valve means for causing refrigerant flow from the outlet portion of either coil functioning as a condenser to the nozzle portion of the ejector associated with the coil functioning as an evaporator.

5. A heat pump operable to provide staged compression for either heating or cooling comprising a compressor, a first heat exchange coil adapted to be coupled to the discharge side of said compressor for normally functioning as a condenser, a second heat exchange coil adapted to be coupled to the suction side of said compressor for normally functioning as an evaporator, a reversing valve operatively interposed between said coils and said compressor for selectively interchanging the functions of said coils, first and second expansion members operatively connected to said first and second coils, respectively, for expanding refrigerant when its respective coil functions as an evaporator, first and second ejectors operatively associated with said first and second coils, respectively, and valve means interposed between said first and second coils for causing the ejector associated with the coil functioning as an evaporator to provide a stage of compression and for causing the other ejector to merely provide a conduit for enabling the flow of refrigerant through the coil functioning as a condenser.

6. A method of obtaining staged compression on either the heating or cooling cycle of a refrigeration system operable on the reverse cycle principle, said refrigeration system having a compressor, a first heat exchange coil, a second heat exchange coil, a first expansion means associated with said first heat exchange coil, a second expansion means associated with said second heat exchange coil, a reversing valve coupled between said compressor and said coils, and an ejector associated with each of said coils, comprising the steps of compressing the refrigerant, condensing said refrigerant in one of said coils passing refrigerant through the expansion means associated with the other of said coils, evaporating refrigerant in the other of said coils, passing refrigerant through the ejector associated with the other of said coils to effect compression of refrigerant and decrease the pressure in the other of said coils, passing said refrigerant to said compressor to repeat said foregoing cycle, and selectively manipulating said reversing valve to interchange the functions of said coils and causing the ejector associated with the coil then functioning as an evaporator to compress refrigerant.

7. A refrigeration system comprising a compressor, a first heat exchange coil and a second heat exchange coil connected to form a circuit for the flow of refrigerant, expansion means serving each coil and including an ejector for transmitting high pressure refrigerant to the coil with which it is associated, said ejector serving to induce flow of refrigerant through the coils, a refrigerant collection and separation vessel interposed between the ejector and coil for transmitting liquid refrigerant to the coil and vaporous refrigerant to the compressor.

8. A refrigeration system according to claim **7** wherein said expansion means includes a restriction interposed between the vessel and the coil to control flow of liquid refrigerant separated in said vessel.

References Cited by the Examiner

UNITED STATES PATENTS

2,044,811	6/1936	Randel	62—116
2,513,361	7/1950	Rausch	62—116
3,103,106	9/1963	Tipton	62—500 X
3,134,241	5/1964	Johnson	62—500 X

LLOYD L. KING, *Primary Examiner.*