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(72) Inventors:
• **Mora, Miguel**
03450 Banyeres de Mariola (Alicante) (ES)
• **Acedo Navarrete, Jose**
E-01010 Vitoria (Araba) (ES)

(74) Representative: **Hocker, Thomas**
Vaillant GmbH
Berghauser Strasse 40
42859 Remscheid (DE)

(71) Applicant: **Vaillant GmbH**
42859 Remscheid (DE)

(54) **SENSOR ARRANGEMENT IN A HEAT PUMP SYSTEM**

(57) The present invention discloses a heat pump system including a refrigerant circuit having a compressor, a first heat exchanger downstream of the compressor for operating as a condenser in a heating mode and operating as an evaporator in a cooling mode, a throttling device downstream of the first heat exchanger, and a second heat exchanger downstream of the throttling device for operating as an evaporator in the heating mode and operating as a condenser in the cooling mode. A reversing valve is disposed in the refrigerant circuit between the compressor and the first/second heat ex-

changer for selectively reversing the refrigerant flow therein. A sensor combination for being used to calculate a present super-heating degree, wherein the sensor combination includes a temperature sensor for detecting a temperature of the refrigerant after leaving from the second heat exchanger and before entering the reversing valve and a second sensor for being used to measure a saturated temperature of the refrigerant at a low pressure side. In this way, the heat pump system can avoid super-heating degree instabilities caused by the reversing valve, thereby improving its performance and efficiency.

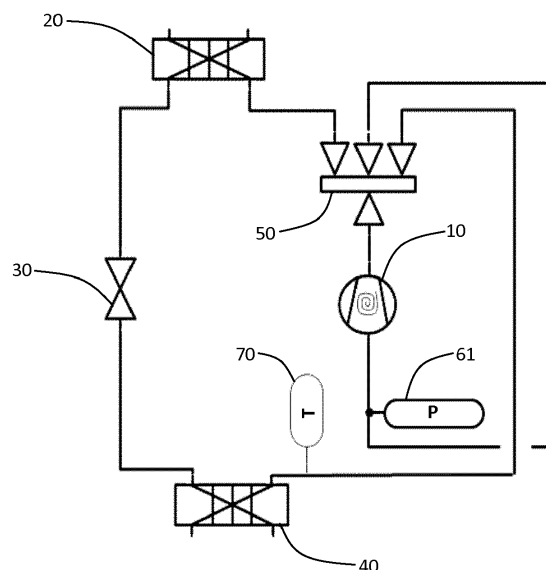


Fig. 1

Description

FIELD OF THE INVENTION

[0001] The present invention relates to a heat pump system, and more particularly to a heat pump system employing a reversing valve for reversing the refrigerant flow so that the system can perform either space heating or space cooling.

BACKGROUND OF THE INVENTION

[0002] Fig.5 shows a conventional heat pump system that can perform either space heating or space cooling. The system has a compressor 81 for compressing a refrigerant, an indoor heat exchanger 82 for cooling the refrigerant in a heating mode and vaporizing the refrigerant in a cooling mode, an expansion valve 83 for lowering the pressure of the refrigerant, and an outdoor heat exchanger 84 for vaporizing the refrigerant in the heating mode and cooling the refrigerant in the cooling mode. A four-way valve 90 is provided between the compressor 81 and the indoor/outdoor heat exchanger 82, 84 to switch a channel of the refrigerant flow. In the heating mode, the hot gas refrigerant leaving from the compressor 81 enters the four-way valve 90 at its port 94, and leaves the four-way valve at its port 91 to discharge to the indoor heat exchanger 82; in the mean time, the cold gas refrigerant discharging from the outdoor heat exchanger 84 passes through the four-way valve 90 via ports 93 to 92, and goes back to the compressor 81. During the period, there is a heat exchange between the hot compressor discharge refrigerant flow and the cool compressor suction refrigerant flow in the four-way valve 90. In the cooling mode, the four-way valve 90 is operable to switch the channel of refrigerant flow in a reverse direction, that is, to switch the refrigerant channel from the compressor 81 to the indoor heat exchanger 82 via ports 94 to 91 to another refrigerant channel from the compressor 81 to the outdoor heat exchanger 84 via ports 94 to 93; meanwhile, the gas refrigerant flow discharging from the indoor heat exchanger 82 passes through the four-way valve 90 via ports 91 to 92, and goes back to the compressor 81.

[0003] A temperature sensor 85 and a pressure sensor 86 are placed in a compressor suction line to measure a suction temperature of the compressor 81 and a saturated temperature at a low pressure side respectively. A present super-heating degree can be calculated from a difference between the suction temperature of the compressor and the saturated temperature at the low pressure side. A controller (not shown) further compares the present super-heating degree with a target super-heating degree which is stored in a storing part of the controller, and then controls the system to reach and maintain the target super-heating degree to prevent the liquid refrigerant flowing into the compressor 81. In other words, the control of super-heating degree assures the refrigerant

evaporation has been finished before entering the compressor 81. The control of super-heating degree is performed by regulating an openness amount of the expansion valve 83.

[0004] As mentioned above, a heat exchange exists in the four-way valve 90, however, this heat exchange is uncontrolled and difficult to predict. The four-way valve introduces many temperature uncertainties that can lead to a problem in the control of the super-heating degree. This problem is that the super-heating degree is difficult to make it steady and set it as most efficient for all conditions. Nowadays, the problem can be solved by setting a higher target super-heating degree. For example, for a normal heat pump system without a four-way valve, the minimum steady super-heating degree can be set at 3K, however, when an additional four-way valve is introduced in the system, the minimum steady super-heating degree has to be set at 7K. This obviously makes the system become less efficient.

SUMMARY OF THE INVENTION

[0005] It is an object of present invention to provide a heat pump system that can avoid super-heating degree instabilities caused by a reversing valve, thereby improving performance and efficiency of the system.

[0006] According to one aspect of the present invention there is provided a heat pump system including a refrigerant circuit having a compressor for compressing a refrigerant, a first heat exchanger downstream of the compressor for operating as a condenser to cool the refrigerant in a heating mode and operating as an evaporator to vaporize the refrigerant in a cooling mode, a throttling device downstream of the first heat exchanger for lowering the pressure of the refrigerant, and a second heat exchanger downstream of the throttling device for operating as an evaporator in the heating mode and operating as a condenser in the cooling mode. A reversing valve is disposed in the refrigerant circuit between the compressor and the first/second heat exchanger for selectively reversing the refrigerant flow therein. A sensor combination for being used to calculate a present super-heating degree, wherein the sensor combination includes a temperature sensor for detecting a temperature of the refrigerant after leaving from the second heat exchanger and before entering the reversing valve and a second sensor for being used to measure a saturated temperature of the refrigerant at a low pressure side. Since the temperature sensor is so positioned that it detects the temperature of the refrigerant before entering the four-way valve, the influence of the reversing valve in determining the super-heating degree can be avoided, thereby assuring the refrigerant evaporation is completely done in the second heat exchanger and no refrigerant in liquid state is sucked into the compressor. Moreover, the system can work more efficiently, because a relatively lower target super-heating degree can be defined.

[0007] Preferably, the temperature sensor is disposed

in the refrigerant circuit between the second heat exchanger and the reversing valve.

[0008] In one embodiment, the second sensor is a pressure sensor disposed in the refrigerant circuit at the compressor suction side.

[0009] In a second embodiment, the second sensor is a pressure sensor disposed in the refrigerant circuit between the second heat exchanger and the reversing valve.

[0010] In a third embodiment, the second sensor is a pressure sensor disposed in the refrigerant circuit between the second heat exchanger and the throttling device.

[0011] In a fourth embodiment, the second sensor is another temperature sensor disposed in the refrigerant circuit between the second heat exchanger and the throttling device.

[0012] Preferably, the reversing valve is a four-way valve operable to switch from one channel of the refrigerant flowing from the compressor to the first heat exchanger to another channel of the refrigerant flowing from the compressor to the second heat exchanger.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] For a more complete understanding of the present invention, and the advantages thereof, reference is now made to the following descriptions taken in conjunction with the accompanying drawings, in which:

Fig. 1 is a diagram showing the configuration of a heat pump system in accordance with a first embodiment of present invention;

Fig. 2 is a diagram showing the configuration of a heat pump system in accordance with a second embodiment of present invention;

Fig. 3 is a diagram showing the configuration of a heat pump system in accordance with a third embodiment of present invention;

Fig. 4 a diagram showing the configuration of a heat pump system in accordance with a fourth embodiment of present invention;

Fig. 5 is a diagram showing the configuration of a heat pump system in the state of art.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0014] Reference will now be made to the drawing figures to describe the preferred embodiments of the present invention in detail. However, the embodiments can not be used to restrict the present invention. Changes such as structure, method and function obviously made to those of ordinary skill in the art are also protected by

the present invention.

[0015] Refer to Fig.1, a heat pump system according to a first embodiment of present invention is capable of performing either space heating or space cooling by using a heating cycle principle for circulating a refrigerant through a refrigerant circuit and a cooling cycle principle for circulating the refrigerant through the refrigerant circuit in a reverse direction. The refrigerant circuit typically includes a compressor 10, a first heat exchanger 20, a throttling device 30, and a second heat exchanger 40. Wherein, the first heat exchanger 20 operates as a condenser in a heating mode and operates as an evaporator in a cooling mode; and the second heat exchanger 40 operates as an evaporator in the heating mode and operates as a condenser in the cooling mode. These components are generally serially connected via conduits or piping, and the operations of these components exemplified in the heating mode will subsequently be described in great detail.

[0016] The compressor 10 generally uses electrical power to compress a refrigerant from a low pressure gas state to a high pressure gas state thereby increasing the temperature, enthalpy and pressure of the refrigerant. The refrigerant leaves from the compressor 10 at a gas state of super-heating degree beyond the saturated state, and then flows through the first heat exchanger 20 for being condensed at a substantially constant pressure to a saturated liquid state. The throttling device 30 can take form of an expansion valve for being used to control the amount of refrigerant entering into the second heat exchanger 40. The liquid refrigerant from the first heat exchanger 20 flows through the expansion valve 30, result in the pressure of the liquid is decreased. In the process, the refrigerant evaporates partially causing the refrigerant to change to a mixed liquid-gas state, reducing its temperature down to a value that makes possible heat exchanges in the second heat exchanger. The second heat exchanger 40 is a heat exchanger where the heat energy available in a secondary flow, such as an external air flow, passes through it and transfers to the refrigerant flow that evaporates inside from liquid to gas. The gas refrigerant discharged from the second heat exchanger 40 is sucked into the compressor 10 and again becomes a gas state of super-heating degree that has evaporated beyond the saturated state.

[0017] The heat pump system also includes a reversing valve 50 disposed in the refrigerant circuit for inversion of the refrigerant cycle. The reversing valve can be in form of a four-way valve placed after the compressor 10 and before the first or the second heat exchanger 20, 40. The four-way valve 50 can be a solenoid operated valve. When the valve is deenergized, the system is in the heating mode, and the refrigerant passes through the four-way valve via a channel from the compressor 10 to the first heat exchanger 20. When the four-way valve is energized, the system works at the cooling mode, and inside of the four-way valve, the channel from the compressor 10 to the first heat exchanger 20 is switched to

another channel from the compressor 10 to the second heat exchanger 40.

[0018] The heat pump system further includes a sensor combination for being used to compute a present super-heating degree. The sensor combination includes a temperature sensor 70 for detecting a temperature of the refrigerant after leaving from the second heat exchanger 40 and before entering the reversing valve 50, and a second sensor 61 for being used to measure a saturated temperature of the refrigerant at a low pressure side. In this embodiment, the temperature sensor 70 is placed in an outlet pipe of the second heat exchanger 40. The second sensor 61 is a pressure sensor placed in the suction pipe of the compressor 10 for detecting the low pressure, and then the detected low pressure is converted into a saturated temperature at the low pressure side. The present super-heating degree can be calculated from a difference between the temperature of the refrigerant at the outlet of the second heat exchanger 70 and the saturated temperature of the refrigerant at the low pressure side.

[0019] Since the temperature sensor 70 is so positioned that it detects the temperature of the refrigerant before entering the four-way valve, the influence of the reversing valve in determining the super-heating degree can be avoided, thereby assuring the refrigerant evaporation is completely done in the second heat exchanger and no refrigerant in liquid state is sucked into the compressor. Moreover, the system can work more efficiently, because a relatively lower target super-heating degree can be defined. For example, the minimum steady super-heating degree can be set at 4K in this case, compared with that (3K) of a normal heat pump system without a four-way valve, it may be a little bit higher, nevertheless, if compared with that (7K) of a traditional heat pump system with a four-way valve, the minimum steady super-heating degree become much lower. Furthermore, this relatively lower target super-heating degree makes the system to be easily reach and maintain it, which results in the superheating becomes more steady, and improving the performance of the compressor accordingly.

[0020] Fig.2 shows a second embodiment of the heat pump system, and the only difference with respect to the first embodiment is that the location of the pressure sensor is moved from the compressor suction side to the position between the second heat exchanger 40 and the reversing valve 50, preferably, the pressure sensor 62 is located in the outlet pipe of the second heat exchanger 40. Fig.3 shows another alternative position of the pressure sensor, wherein, a pressure sensor 63 is positioned between the second heat exchanger 40 and the throttling device 30. Fig.4 shows a fourth embodiment of the system, and the only change with respect to the third embodiment is that the pressure sensor is replaced with another temperature sensor 64 that is able to directly detect the saturated temperature at the low pressure side.

[0021] It is to be understood, however, that even

though numerous, characteristics and advantages of the present invention have been set forth in the foregoing description, together with details of the structure and function of the invention, the disclosed is illustrative only, and changes may be made in detail, especially in matters of number, shape, size, and arrangement of parts within the principles of the invention to the full extent indicated by the broadest general meaning of the terms in which the appended claims are expressed.

Claims

1. A heat pump system comprising:

a refrigerant circuit comprising a compressor (10) for compressing a refrigerant, a first heat exchanger (20) downstream of the compressor for operating as a condenser to cool the refrigerant in a heating mode and operating as an evaporator to vaporize the refrigerant in a cooling mode, a throttling device (30) downstream of the first heat exchanger for lowering the pressure of the refrigerant, and a second heat exchanger (40) downstream of the throttling device for operating as an evaporator in the heating mode and operating as a condenser in the cooling mode;

a reversing valve (50) disposed in the refrigerant circuit between the compressor (10) and the first/second heat exchanger (20/40) for selectively reversing the refrigerant flow therein;

a sensor combination for being used to calculate a present super-heating degree, said sensor combination comprising a temperature sensor (70) for detecting a temperature of the refrigerant after leaving from the second heat exchanger and before entering the reversing valve and a second sensor (61, 62, 63, 64) for being used to measure a saturated temperature of the refrigerant at a low pressure side.

2. A heat pump system according to claim 1, wherein said temperature sensor is disposed in the refrigerant circuit between the second heat exchanger and the reversing valve.

3. A heat pump system according to claim 1, wherein said second sensor is a pressure sensor (61) disposed in the refrigerant circuit at the compressor suction side.

4. A heat pump system according to claim 1, wherein said second sensor is a pressure sensor (62) disposed in the refrigerant circuit between the second heat exchanger and the reversing valve.

5. A heat pump system according to claim 1, wherein

said second sensor is a pressure sensor (63) disposed in the refrigerant circuit between the second heat exchanger and the throttling device.

6. A heat pump system according to claim 1, wherein said second sensor is another temperature sensor (64) disposed in the refrigerant circuit between the second heat exchanger and the throttling device. 5
7. A heat pump system according to claim 1, wherein said reversing valve is a four-way valve operable to switch from one channel of the refrigerant flowing from the compressor to the first heat exchanger to another channel of the refrigerant flowing from the compressor to the second heat exchanger. 10 15

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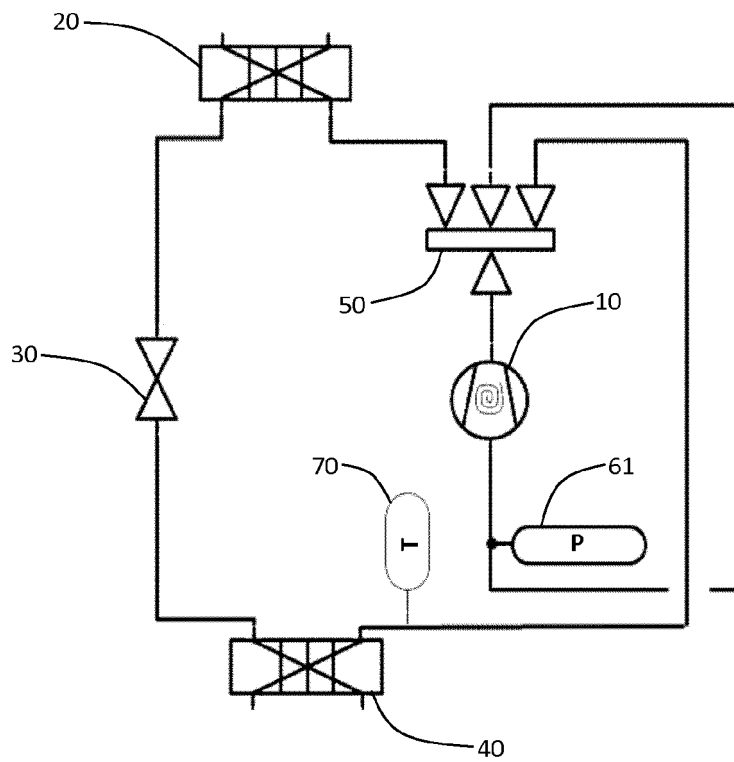


Fig. 1

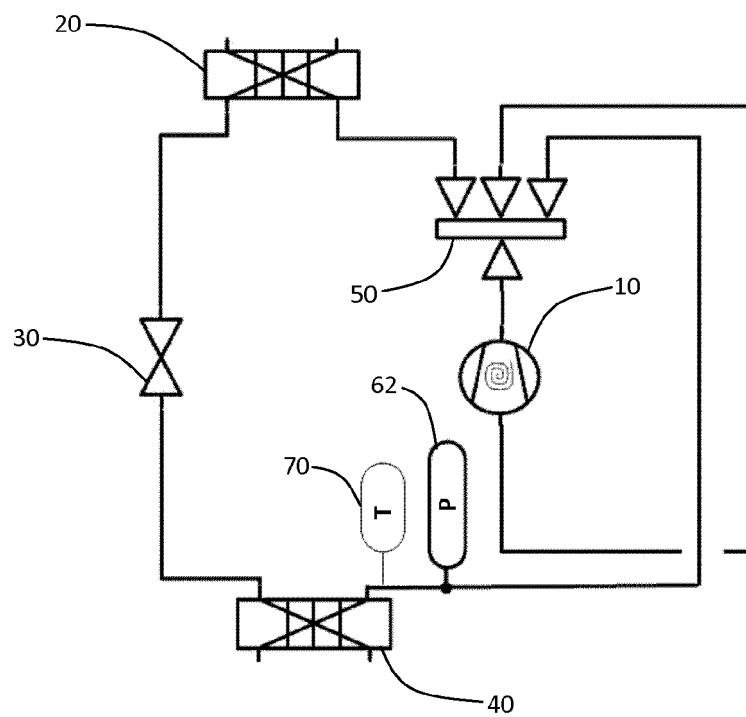


Fig. 2

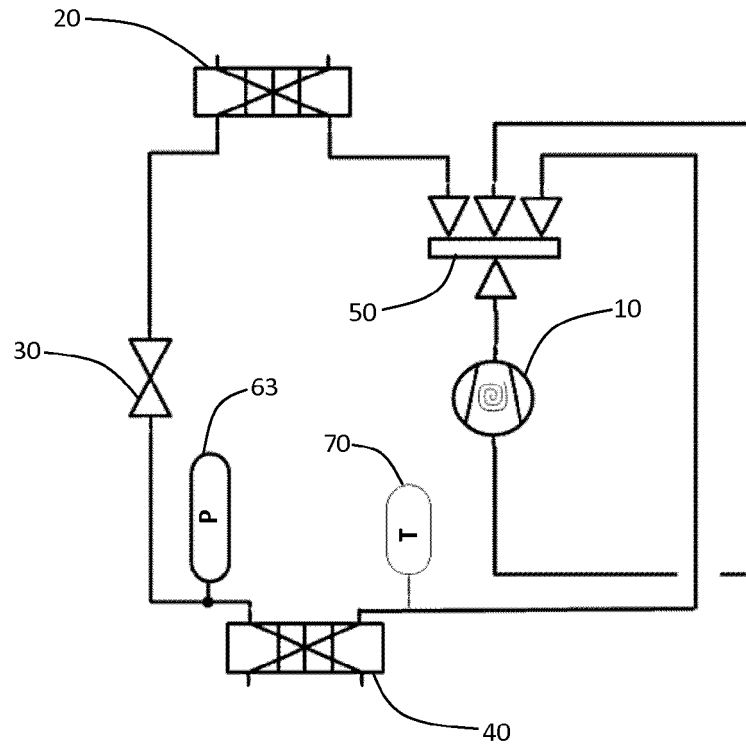


Fig. 3

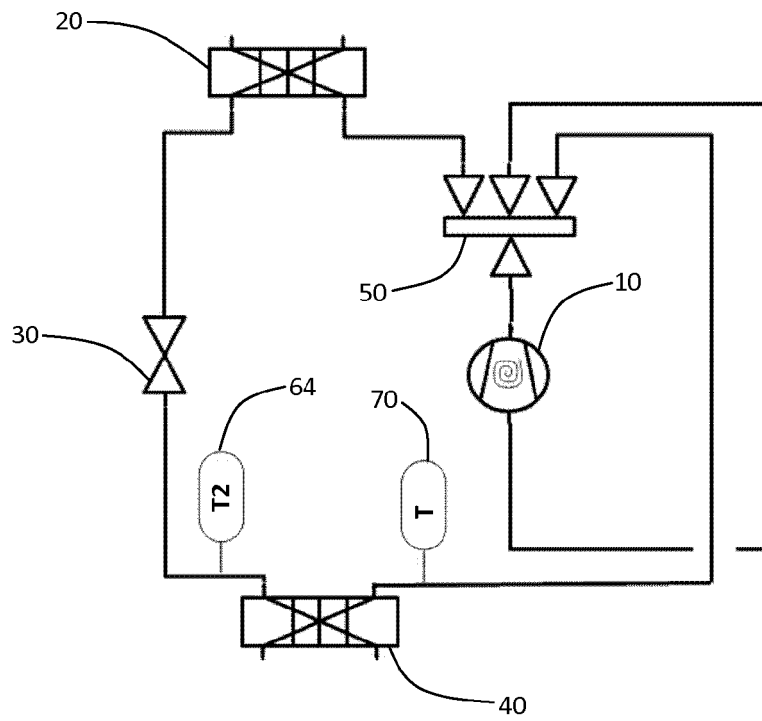


Fig. 4

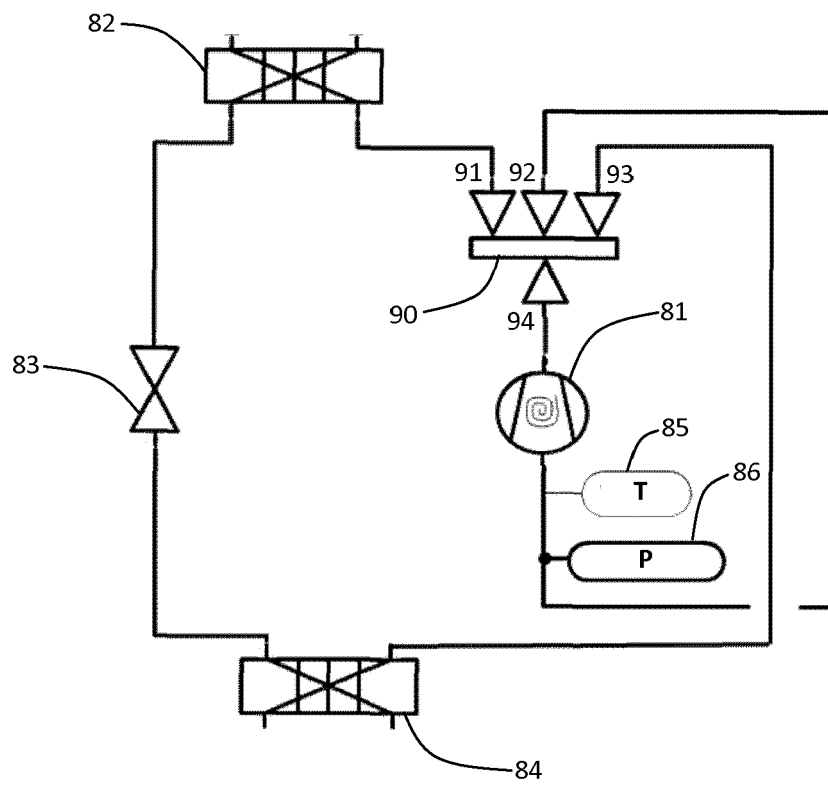


Fig. 5 (state of art)



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