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(54) **Combined refrigeration and air conditioning system**

(57) The invention relates to a combined refrigeration and air conditioning system, which simultaneously carries out the functions of an industrial cold and air conditioning system of an installation or premises by means of refrigeration cycles by direct expansion of a refrigerant.

To that end, it comprises two or more compressors (10, 20) sending the compressed refrigerant to a common

point, a series of expansion valves (12, 22) and several heat exchangers (11, 13, 23), two of which carry out the exchange with the medium to be cooled with the industrial cold system and with the premises or installation to be air conditioned.

The operation mode of the air conditioning system is easily changed from heating to refrigeration by means of the action of two series of valves (50, 51).

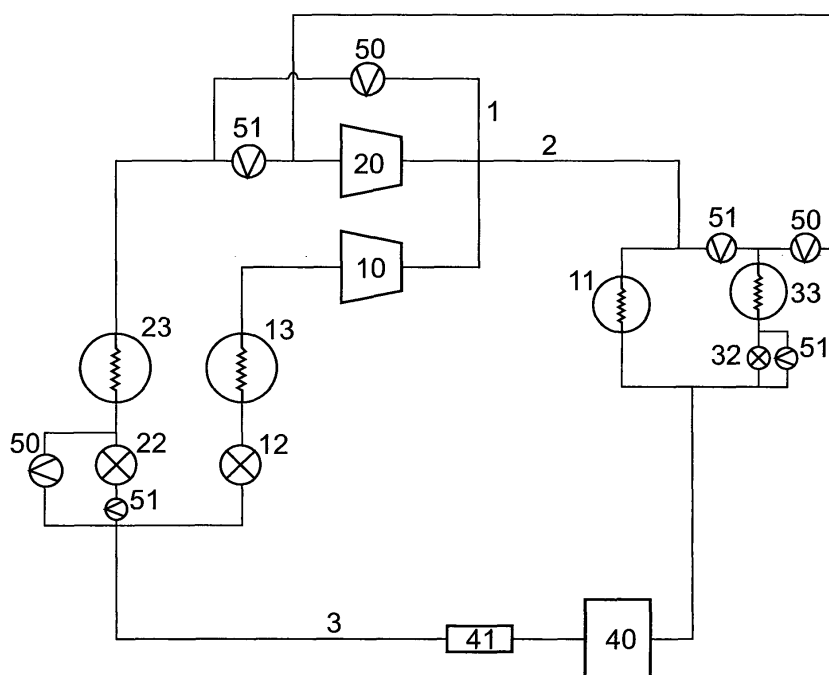


FIG. 3

Description

Field of the Invention

[0001] The present invention relates to a combined refrigeration and air conditioning system which allows improving the efficiency of cold energy conversion in installations requiring air conditioning, either providing cold or heat, and the refrigeration of chambers, displays or any other object or medium at least temporarily.

[0002] The system can particularly be used in a refrigerator installation of premises that are also provided with a comfort air conditioning system such as for example a refrigeration unit with one or more displays of goods in a store with an air conditioning system.

State of the Art

[0003] The invention belongs to the sector of the art of air conditioning and refrigeration.

[0004] The premises in which perishable products are stored or sold to the public always have two thermal systems, independent from one another, working in an independent and isolated manner. On one hand, there are industrial cold systems characteristic of perishable products and on the other hand, there are comfort air conditioning systems of the premises itself.

[0005] The industrial cold installation most frequently comprises a conventional mechanical compression refrigeration system, and the air conditioning systems of the premises are provided with air-air heat pumps.

[0006] A basic mechanical compression and refrigeration cycle by direct expansion consists of four elements or steps: compressor, condenser, expansion valve and evaporator.

[0007] In the evaporator, the refrigerant evaporates and absorbs heat from the space that it is cooling and from its content. The refrigerant vapor then passes to a compressor increasing its pressure, which increases its temperature. This high pressure overheated gas is subsequently transformed into a liquid in a condenser that is refrigerated by air or water.

[0008] After the condenser, the liquid passes through an expansion valve, where its pressure and temperature are reduced until reaching the conditions existing in the evaporator inlet, the cycle being closed.

Description of the Invention

[0009] The present invention relates to a complete and unique refrigeration and air conditioning system currently comprising two independent subsystems, which are the industrial cold system and the air conditioning system for the premises (the latter can heat or cool according to the comfort needs).

[0010] By taking advantage of these two subsystems, energy savings are obtained upon achieving the operation of the heat pump of the main system with the basic

elements of industrial cold and air conditioning installations.

[0011] This system offers energy saving as the condensation phases of the compressors and the complete compression systems of cold and air conditioning installations are optimized. This saving occurs in heating the premises in winter and in taking advantage of the efficiency of higher capacity equipment in summer.

[0012] Furthermore, the process allows improving the safety and reliability of the main power systems and compressors of the main system because, by the grouping thereof, backups are obtained when any of them fails. The air conditioning systems will mainly back industrial cold systems, given that their operation is the top priority so that refrigerated or frozen products do not spoil.

[0013] The present invention therefore relates to the combination of industrial cold and air conditioning systems in a single system. The residual energy of one of them, generally the industrial cold system, is used to carry out the air conditioning of the premises by means of the heat pump formed.

[0014] The proposed system is formed by a traditional refrigeration system, which could be completed with an additional subsystem such as controlled electronic injection or liquid pump for greater energy saving.

[0015] In a mechanical compression refrigeration cycle, heat is always absorbed from a cold spot, furniture, chambers of the center all year round and is delivered to a hot spot during condensation.

[0016] According to the invention, this hot spot will correspond to the premises during the period in which it must be heated (denominated winter herein, regardless of the season in which it occurs and of its duration) through the air conditioning system. With the invention, the heat generated by all or part of the condensers of the industrial cold installation, which was previously degraded, is taken advantage of in the air conditioning of the premises. When necessary, this heat source will be accompanied by other sources such as electric resistances, hot water, steam, solar energy or another energy source.

[0017] When the temperature of the premises is to be reduced, a period which will be denominated summer, it will be necessary to maintain the industrial cold system and activate the air conditioning system of the premises in parallel for cooling. In this period, the main cold power system will be used for the two subsystems as a traditional installation, but taking advantage of the combination of the two systems to seek a higher efficiency, using higher capacity equipment.

[0018] Two subsystems, denominated positive cold and negative cold subsystems, are frequently installed in industrial cold systems, each of such subsystems allows cooling up to a certain temperature. The negative cold subsystem cools up to a temperature that is lower than that of positive cold; between -10°C and -35°C for example.

[0019] In this manner, the negative cold subsystem can be used to preserve frozen products, whereas the

positive cold subsystem can be used for refrigerated products (butter, fish, meat, etc.)

[0020] Both subsystems may share elements, but they are generally provided independently for safety reasons due to possible leakages.

[0021] The existence or non-existence of a separation into two subsystems will not be mentioned hereinafter, interpreting that in the event that there is a division into the two positive cold and negative cold subsystems, the combination of the air conditioning system and industrial cold system can be carried out with any of the two subsystems, or even with both (further increasing the energy efficiency).

[0022] In any case, it is usually more interesting to carry out the combination with the positive cold subsystem.

[0023] To that end, the system of the invention comprises two compressors, or two pluralities of compressors in series or in parallel, denominated first and second compressor, the outlet of compressed refrigerant of which is at a common point. The flow of refrigerant from this common point to the inlet of the compressors will vary according to the operation mode such that:

[0024] In the summer operation mode, a first heat exchanger carries out refrigerant condensation functions after the common point, and will pour the condensed refrigerant in two parallel branches, each of which comprises an expansion valve, either of the electronic, mechanic or constant overheating type or of any other type, and a heat exchanger acting as an evaporator.

[0025] In particular, in a first branch the refrigerant traverses a first expansion valve and a second heat exchanger, which will remove heat from the medium which is to be cooled by means of the industrial cold system. In the other branch it will traverse a second expansion valve and a third heat exchanger which exchanges heat with the premises or installation which is to be cooled, in this case by cooling it.

[0026] After the second and third exchanger, it returns to the suction inlets of the compressors, which inlets can be connected so that one compressor backs the other in the event of failure.

[0027] In the winter operation mode, the refrigerant will follow a first branch from the common point reaching the third heat exchanger, which in this case will condense the refrigerant and will provide the extracted heat to the premises or installation to be conditioned and at the outlet of which the first expansion valve and the second exchanger are arranged, which second exchanger continues working as an evaporator and removing heat from the medium object of the industrial cold.

[0028] Optionally and to achieve a greater variability between the heat provided to the premises and the heat extracted by means of the industrial cold system, a second branch starting at the common point and following the first heat exchanger, which will condense the refrigerant, can be created. From this point and through a section which can optionally comprise a liquid pump or a tank, the refrigerant enters the first expansion valve. The

negative calories of the industrial cold system can thus be increased without affecting the air conditioning system.

[0029] On the other hand, if more heating is desired in the air conditioning system without varying the negative calories provided by the industrial cold system, the refrigerant can be drawn from outlet of the third exchanger to a third expansion valve followed by a fourth exchanger evaporating the refrigerant, removing heat from an element outside both air conditioning and industrial cold systems. The refrigerant will finally return to a compressor, for example the second compressor.

[0030] Two series of valves, the opening and closing of which defines the operation mode of the system (summer or winter), can be advantageously arranged to change from one operation mode to another. These valves can be manually actuated by servomotors controlled by an automaton, or by any other means.

[0031] The most evident variant which can be applied to this basic installation is the existence of several compressors in series or in parallel, substituting the first or second compressor. In the same manner, any heat exchanger or any expansion valve can be substituted with several exchangers or several expansion valves in series or in parallel, respectively.

[0032] Another variant is to use the fourth exchanger, which according to the described operation only acts in winter, as a condenser in summer. To that end, the third expansion valve must be bridged.

[0033] The system is self-regulated by the temperatures detected in each of the objects, premises and installations which are to be cooled or air conditioned, such as for example perishable product displays, refrigeration chambers and sale rooms.

[0034] For the purpose of assuring the comfort of the installation, a back up system can be provided for the air conditioning system in winter periods by means of electric resistances, batteries for hot water, boilers or other means, in which periods it is necessary to heat the building even more to carry out sales in the center either due to extremely low temperatures or due to a failure of the compression system.

[0035] Refrigerant flow control equipment will be installed to carry out power changes in either direction, either refrigeration or air conditioning. This equipment will be formed by:

- mechanical control valves
- electronic control valves
- pressure and temperature control automatons

[0036] Any type of equipment required by a refrigeration installation such- as safety valves against overpressure, manometers, bleed valves, refrigerant tanks, etc. will also be installed.

Description of the Drawings

[0037] To aid in better understanding the invention, an embodiment of the invention is very briefly described below as an illustrative and non-limiting example thereof. To that end, reference is made to the attached drawings, in which:

Figure 1 shows a summer operation scheme, whereas Figure 2 shows the winter operation.

Finally, Figure 3 shows a possible general scheme for the connection of the combined system.

Description of an Embodiment

[0038] The combined refrigeration and air conditioning system consists of an air conditioning system which can refrigerate or heat the environmental air of a premises, and an industrial cold system, which can in turn be divided into an independent positive cold subsystem and a negative cold subsystem or with common elements.

[0039] The air conditioning system recovers part of the energy which the industrial cold system was previously going to waste, operating in two different modes.

[0040] To that end, the operation must be separated into two modes, one will be denominated summer, in which the air conditioning must cool the environment, and the other will be denominated winter, in which the air conditioning must heat the premises.

[0041] The industrial cold system will comprise a first compressor (10), a first heat exchanger (11) acting as a condenser, a first expansion valve (12) and a second heat exchanger (13) acting as an evaporator. However, the air conditioning system will comprise a second compressor (20), a second expansion valve (22) and two heat exchangers, one of them evaporating and the other one condensing.

[0042] Each of the mentioned equipment can actually correspond to a plurality of equipment placed in series or in parallel. Thus, for example, there can be a plurality of first compressors (10) arranged in parallel or a plurality of first exchangers (11).

[0043] As can be seen in Figure 1, the summer operation mode is less complex, given that the refrigerant is common for both systems (where appropriate, between one or both positive or negative cold subsystems, generally the former and the air conditioning system). Both systems are further placed in parallel, such that the refrigerant traverses the first exchanger (11). It is convenient to place at least two exchangers in parallel to better adjust the power and if necessary, to be able to disconnect one of the two exchangers in order to carry out the maintenance, to repair the other exchanger, or even when the one of the two exchangers has the sufficient capacity, to condense all the refrigerant by itself.

[0044] After said first exchanger (11), and after a tank (40) and a liquid pump (41), both of which are optional, the flow lines are separated in two branches, a first flow

line traversing the first expansion valve (12) and the second exchanger (13) acting as an evaporator in the industrial cold system, before returning to the first compressor (10), whereas the second flow line traverses the second expansion valve (22) and a third exchanger (23) (acting as an evaporator of the air conditioning system, and cooling the premises) and returns to the second compressor (20).

[0045] To change to the winter operation, the valves are opened and closed so that the schematic arrangement changes to that corresponding to Figure 2.

[0046] Said Figure 2 shows both compressors (10, 20) arranged in a manner similar to the previous one, but with an important variation in the arrangement of the exchangers (11, 13, 23).

[0047] After the common point, located at the outlet of both compressors (10, 20) a first branch (1) takes the compressed refrigerant to the third exchanger (23) or air conditioning battery, acting as a condenser instead of an evaporator, providing heat to the premises instead of cooling it. This heating method can be supplemented by other heat sources such as electric resistances, hot water, steam, solar energy or any other energy source.

[0048] After the third exchanger (23), the fluid traverses the first expansion valve (12) and the second exchanger (13), which continue to carry out the same functions as in the summer mode, to return to the first compressor (10).

[0049] In short, only the third exchanger (23) changes its operation between condenser and evaporator. To that end, it must be taken into account that both a condenser and an evaporator are heat exchangers and can operate in either manner according to the temperature of the fluids exchanging heat, it being possible for one fluid to condense while the other fluid evaporates.

[0050] It is possible to provide a first variation to this scheme to unbalance the cooling and heating capacity of both systems in winter.

[0051] If the power of the industrial cold system is to be increased, the flow is divided from the common point located at the outlet of both compressors (10, 20), the refrigerant being able to go through two different branches (1, 2) instead of only one.

[0052] The second branch (2) takes part of the refrigerant to the first exchanger (11), which continues to carry out the condensation. From this point, the condensed refrigerant reaches the first expansion valve (12), where it is pooled with the rest of the refrigerant. In this manner, some of the refrigerant which has not condensed in the air conditioning system evaporates in the industrial cold system, in a manner similar to the summer mode. To that end, the lower section (3) must be traversed in the example shown in the figures.

[0053] The refrigerant flow through this second branch (2) can be taken to a point such that no condensation is carried out in the third exchanger (23) when the temperature of the premises is suitable for sales and does not require air conditioning (mode between seasons).

[0054] On the other hand, if more heating is desired in the air conditioning system, without varying the negative calories provided by the industrial cold system, the refrigerant flow passing through the third exchanger (23) is increased and the refrigerant is divided, part of the refrigerant reaching the first expansion valve (12) and the second exchanger (13), whereas the rest of the refrigerant reaches a third expansion valve (32) and a fourth exchanger (33) through the lower section (3), which exchanger evaporates the refrigerant, using the negative calories for something other than the industrial cold system (or discarding them).

[0055] It is also possible to provide more heat to the air conditioner by means of an external heat source.

[0056] The following variant uses the fourth exchanger better: changing the operation of the fourth exchanger (33), making it condense the refrigerant in parallel with the first exchanger (11) in the summer operation. To that end, a small change must be made in the connections of the elements of the invention which are considered to be evident for a person skilled in the art (placing a bypass of the third expansion valve (32) which may or may not be activated and the circuits and valves necessary to reorient the flow).

[0057] It can be seen in Figure 2 that the lower section (3) does not have any defined flow direction in the winter operation, rather the refrigerant circulation direction varies between two points before the third expansion valve (32) and the first expansion valve (12) according to the refrigerant pressure difference at both points.

[0058] The tank (40) in which the refrigerant passing through the combined refrigeration system and the aforementioned liquid pump (41) is stored can optionally be placed in this lower section (3).

[0059] Figure 3 shows an installation scheme according to the invention showing, in a simplified manner, all the elements of the invention, and two series of preferably automatic valves (50, 51) which allow selecting the operation mode.

[0060] The summer operation occurs when the first series of valves (50) is closed and the second series of valves (51) is opened. The winter operation occurs if the first series of valves (50) is opened and the second series of valves (51) is closed.

[0061] This scheme must be completed with the usual safety and maintenance measures in refrigeration systems, such as flow meters, bleed valves, safety valves, manometers,... etc. It is considered that these measures are known by persons skilled in the art and are also frequently demanded and established by current regulations and do not need to be described.

[0062] For example, a connection can be installed between the suction inlets of the compressors (10, 20) so that one can back the other in the event of a hypothetical failure of one of the two systems.

[0063] The cycle condensation means may comprise one or more condensers cooled by air, water, evaporative condensers or condensers of any other type, outside the

premises with an axial type fan or inside the premises with a centrifugal type fan, or any other equipment compatible with the precise energy source for condensation, designed to a great extent for positive cold and air conditioning systems in one of them and negative cold systems for the other. This equipment is standard equipment which is normally installed in these installations.

[0064] Furthermore, and repeating that mentioned previously, each of the elements of the system can be substituted by a plurality of elements of the same type placed in series or in parallel.

[0065] This process can be carried out with any known refrigerant, refrigerants R404a, R507 or R134a for example.

Claims

1. A combined refrigeration and air conditioning system, based on a refrigeration cycle by direct expansion of a refrigerant, **characterized in that** it carries out the functions of an industrial cold and air conditioning system of an installation or premises, and **in that** it comprises:

- a first and a second compressor (10, 20), the compressed refrigerant outlet of which is at a common point;
- a first, second, and third heat exchanger (11, 13, 23), the second exchanger (13) exchanging heat with the medium to be cooled by means of the industrial cold system, and the third exchanger (23) exchanging heat with the installation or premises;
- a first and a second expansion valve (12, 22);
- a first and a second series of valves (50, 51);

and **in that** in a first operation mode, denominated summer:

- after the common point, the first exchanger (11) condenses the refrigerant, and pours the condensed refrigerant into two parallel branches, each of which comprises an expansion valve (12, 22) and a heat exchanger (13, 23) acting as an evaporator, before the entrance into the compressors (10, 20); and

in a second operation mode, denominated winter:

- after the common point the refrigerant takes a first branch (1) and consecutively traverses the third exchanger (23) acting as a condenser, the first expansion valve (12) and the second exchanger (13) before being reintroduced in the first compressor (10);

and **in that**:

the two series of valves (50, 51) allow the change from one operation mode to the other, such that the summer operation occurs when the first series of valves (50) is closed and the second series of valves (51) is opened, and the winter operation occurs when the first series of valves (50) is opened and the second series of valves (51) is closed. 5

2. A system according to claim 1, **characterized in that** 10
in the winter mode and after the common point, part of the refrigerant takes a second branch (2), in which the refrigerant traverses the first exchanger (11) acting as a condenser of the refrigerant before being introduced in the first expansion valve (12). 15
3. A system according to claim 1, **characterized in that**
in the winter mode, after the third exchanger (23) acting as a condenser of the refrigerant, part of the refrigerant traverses a third expansion valve (32) and 20
a fourth heat exchanger (33), before being reintroduced in the second compressor (20).
4. A system according to claim 3, **characterized in that**
in the summer mode, the third expansion valve (32) 25
is bridged and the fourth exchanger (33) acts as a condenser in parallel with the first exchanger (11).
5. A system according to any of claims 1 to 4, **characterized in that** it is completed with a liquid pump 30
(41) between at least one exchanger (11, 23, 33) acting as a condenser and an expansion valve (12, 22, 32)
6. A system according to any of claims 1 to 5, **characterized in that** at least one of the compressors (10, 35
20) corresponds to a plurality of compressors placed in series or in parallel.
7. A system according to any of claims 1 to 6, **characterized in that** at least one of the heat exchangers 40
(11, 13, 23, 33) corresponds to a series of exchangers arranged in series or in parallel.
8. A system according to any of claims 1 to 7, **characterized in that** it comprises a connection between 45
the suction inlets of the compressors (10, 20).
9. A system according to any of claims 1 to 8, **characterized in that** the air conditioning system comprises 50
other heat sources in the winter mode.

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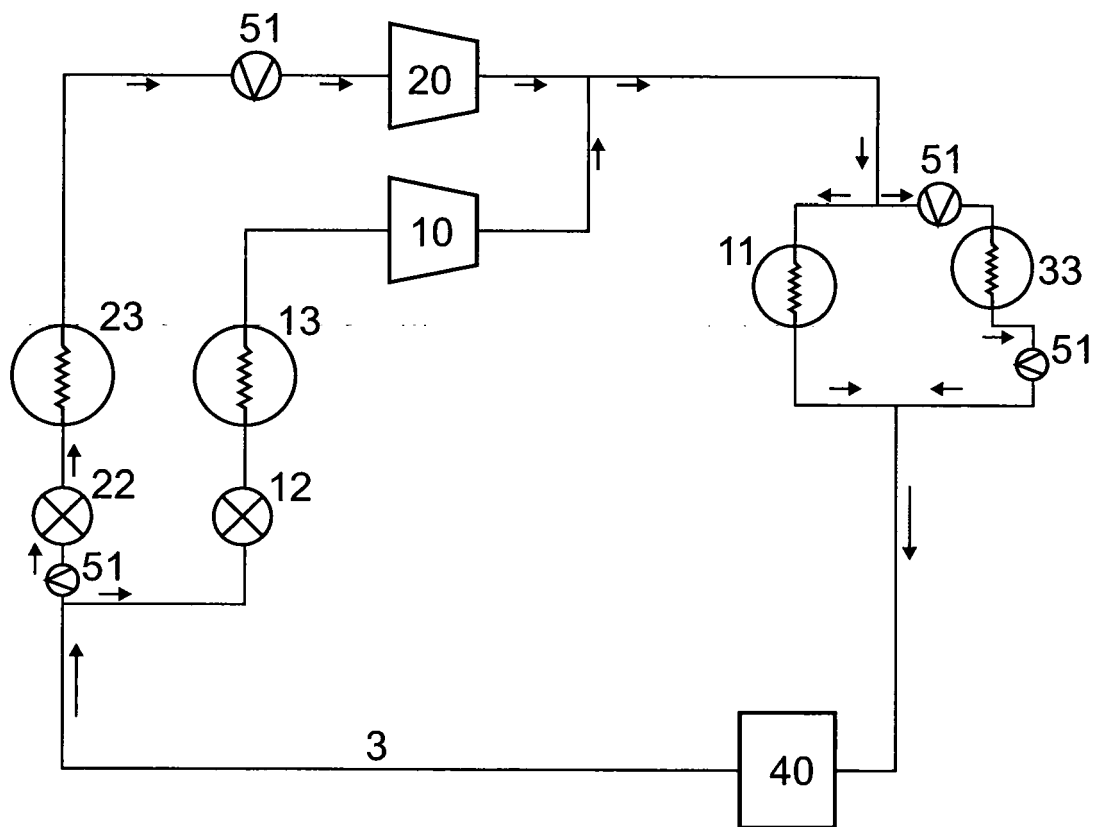


FIG. 1

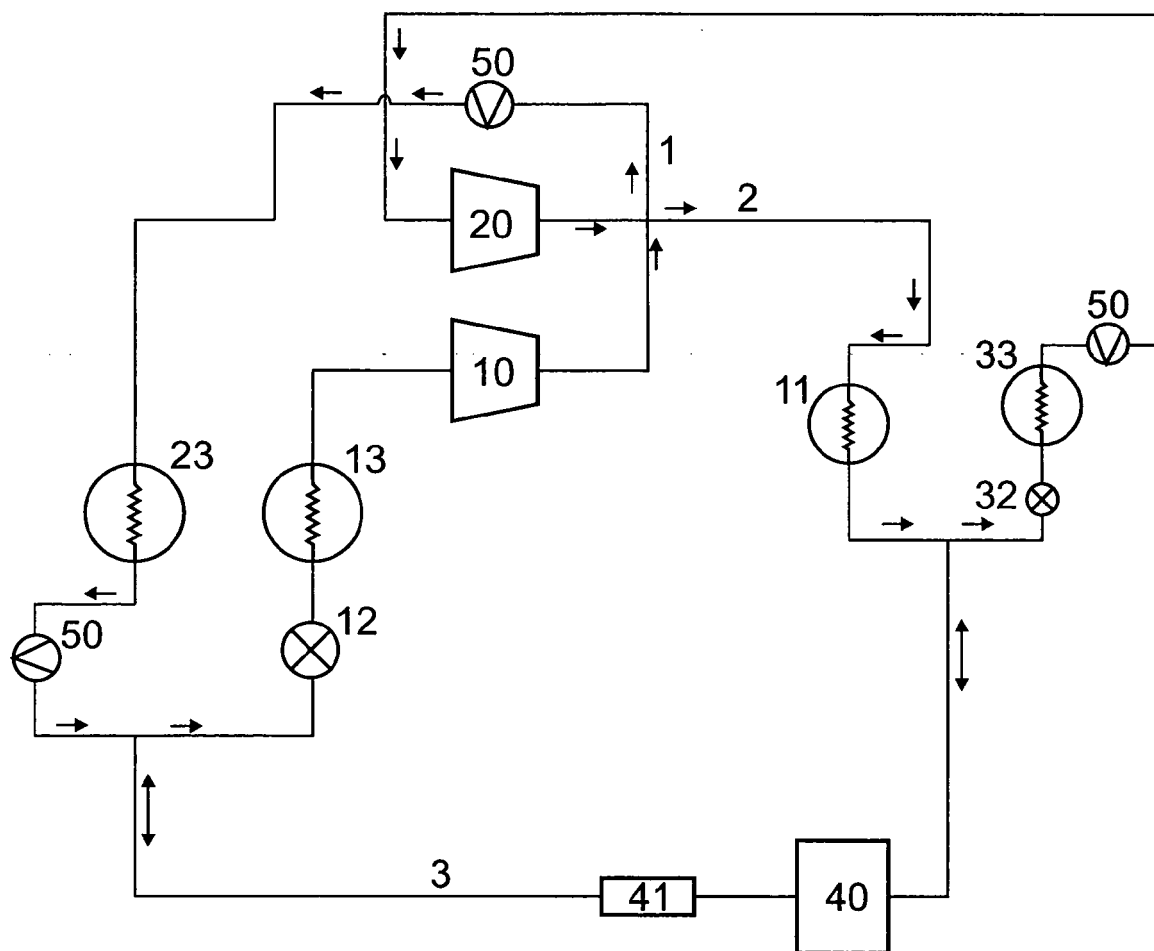


FIG. 2

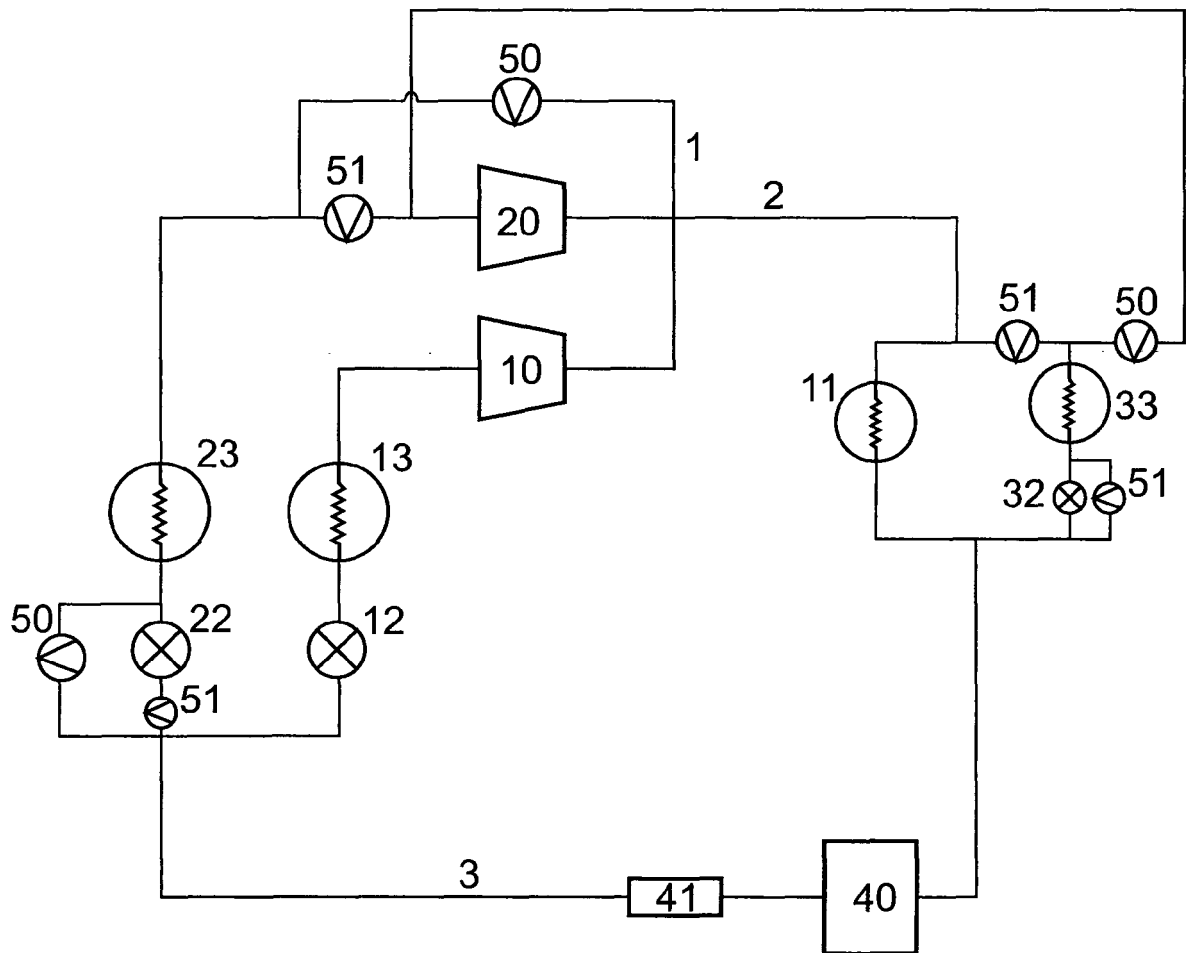


FIG. 3