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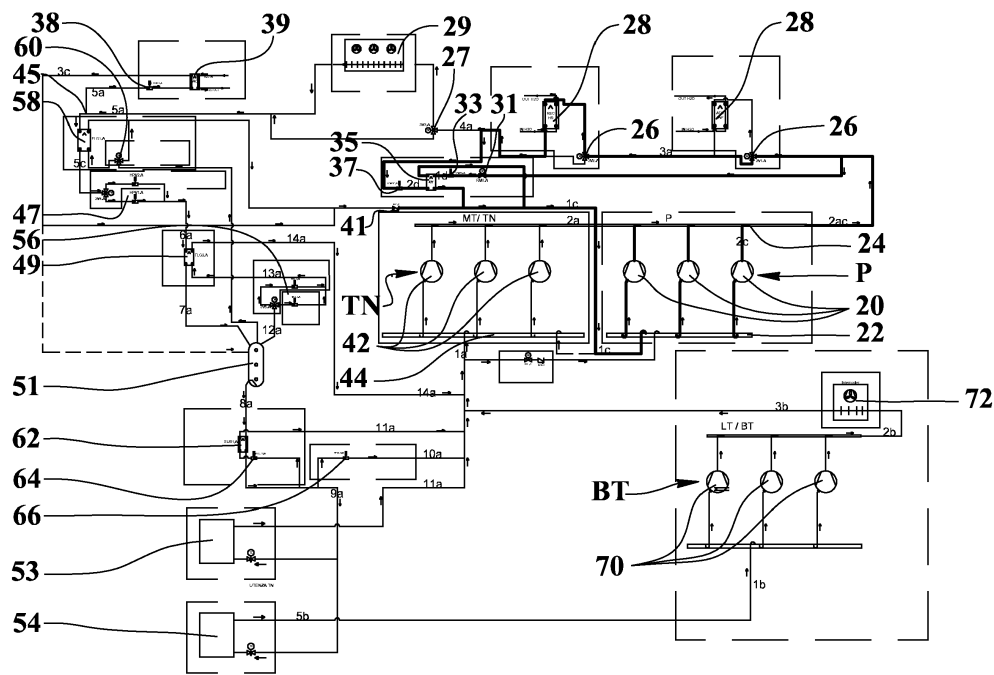
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(54) REFRIGERATION PLANT FOR REFRIGERATION AND AIR CONDITIONING

(57) A refrigeration plant for refrigeration and air conditioning comprises at least a first set (P) of compressors (20) whose inlets for the plant refrigerating fluid are connected to a common first inlet collector means (22) and whose outlets are connected to a common first outlet collector means (24) connected to a first pipe provided with a set of shunt means (26, 27) for the refrigerating fluid each one assigned to insert or separate from said

first pipe a respective first heat exchanger (28, 29) in the state of insertion along the first pipe, assigned to transfer to a secondary fluid the refrigerating fluid heat cooling or condensing the latter. Said first pipe is also provided with a first branch having a first valve means (31) for opening and closing the first branch that is connected to the first pipe between the first outlet collector means (24) and the shunt means (26, 27).

**FIG.2****EP 3 002 529 A1**

Description

[0001] The present invention relates to the field concerning the refrigeration and the air conditioning and in particular it relates to a refrigeration plant able to ensure simultaneously to several users (for example two or three separate users) respective and distinct levels of temperature, for example keeping them at normal refrigeration temperature (with TN indicatively ranging from - 10° C to + 5°) at low temperature (with BT indicatively ranging from - 40° C to -15° C) and at a temperature of air conditioning for commercial rooms (with AC ranging from + 10° C to + 30° C) as may be required, for example, in food distribution.

[0002] There are known systems able to provide to multiple users respective refrigeration or air conditioning. Such known systems consist of many refrigeration plants so many are the users with different requirements.

[0003] A drawback of such known systems consists in that they are not many efficient and have high energy consumption.

[0004] Other drawback consists in that they have very high overall dimensions thus requiring a lot of expensive space.

[0005] Further drawback of the known systems consists in that contain a high number of expensive components and they are very complex requiring a lot of costly maintenance and resulting complex, and difficult to install.

[0006] Document No. EP2479518 discloses a refrigeration plant having the features of the preamble of claim 1 of the present document.

[0007] One object of the present invention is to propose a refrigeration plant at least for the winter and summer air conditioning (AC) of a user, able to maximize the performance. Other object is to propose a plant able to heat also using the heat otherwise dissipated in the environment.

[0008] Other object is to propose a plant able to operate to produce hot water for sanitary use (50-80° C) recycling heat otherwise dissipated in the environment or through a real generation.

[0009] Further object is to propose a single plant to provide to almost all types of users (heating, domestic hot water production, air conditioning, normal temperature refrigeration (TN) and/or low temperature refrigeration (BT)) and able to maximize the performance of the entire system and thus to obtain the maximum energy saving in each operating condition, or partial or total deactivation of one or more users in order to provide, with a single installation, the maximum benefit to a user such as, for example, a supermarket or a shopping center.

[0010] Other object is to propose a plant able to heat a user without heat exchanges with the external environment and therefore without be limited by the outside temperature as in the known heat pumps.

[0011] Other object is to propose a plant able to use natural refrigerants, such as carbon dioxide, or any other

type of synthetic and not synthetic refrigerant.

[0012] Further object is to propose a very simple plant to be installed by the connection in "classic" way of the various users for the refrigeration at normal temperature TN or low temperature BT and for the winter heating and/or the summer air-conditioning and/or for the production of sanitary water.

[0013] Other object is to propose an economic plant to buy, to conduct and to maintain and at least tolerant to certain types of faults.

[0014] Further object is to propose a relatively simple plant and provided with a reduced number of components for an improved reliability.

[0015] Other object is to propose a plant of reduced dimensions.

[0016] The refrigeration plant of the present invention is able to provide heat or refrigeration independently from the requests of the users TN and LT; therefore, for the four different users (conditioning, sanitary hot water production, normal temperature refrigeration and low temperature refrigeration), the plant operates exactly as four stand-alone plants without limits due to ties connection cycles.

[0017] The characteristics of the invention are highlighted in the following with particular reference to the accompanying drawings in which:

- Figure 1 shows a schematic view of the pressure/enthalpy diagram of cycles of the refrigeration plant for refrigeration and air-conditioning, object of the present invention, in the case of refrigerating fluid consisting in carbon dioxide and wherein the main states are indicated by respective alphanumeric references;
- Figure 2 shows a schematic view of the plant of the invention in which the portions concerned by a first operation are in bold highlighted and wherein also the references of Figure 1 are reported;
- Figure 3 shows a schematic view of the plant of the invention in which the portions concerned by a second operation are highlighted in bold and wherein also the references of Figure 1 are reported.

[0018] With reference to Figures 1 - 3, numeral 1 indicates the refrigeration plant for refrigeration and air-conditioning comprising at least a first set P of compressors 20 (in a number equal to or greater than one) whose inlets for the plant refrigerating fluid are connected to a common first inlet collector means 22 and whose outlets are connected to a common first outlet collector means 24 connected to a first pipe for the refrigerating fluid.

[0019] In the following the sequence order of the elements of the pipes, derivations and connection sections of the plant is in agreement with the direction of the flow of the refrigerating fluid that runs through them.

[0020] Such first pipe is equipped with a set of shunt means 26, 27 of the refrigerating fluid, for example of motorized diverter valve type and actuated in remote by

a control means, for example of digital microprocessor and programmable kind.

[0021] Each shunt means 26, 27 is assigned to insert or isolate from said first pipe a respective first heat exchanger 28, 29 assigned, in the insertion condition along the first pipe, to yield to a secondary fluid the heat of the refrigerant fluid, which passes through it, cooling the refrigerating fluid itself.

[0022] One of the first heat exchangers 28 can be used for the production of sanitary hot water, in such case the secondary fluid consists in the sanitary water that is heated to a temperature ranging from 50° C to about 80° C with a big economic advantage from the exploitation of thermal energy that otherwise would be lost in the environment.

[0023] One or more other first heat exchangers 28, 29 may be assigned for the heating, in such case the secondary fluid may consist for example in water for heating or in air for one or more users to be heated.

[0024] Possibly one of the first heat exchangers 29 can be used to disperse the excess heat to the outside for the only cooling or condensation of the refrigerating fluid.

[0025] Said first pipe is also provided with a first shunt, i.e. of a side branch of the first pipe for the refrigerating fluid. This first shunt is connected to the first main pipe downstream of the first outlet collector means 24 and upstream of the shunt means 26, 27 and it is provided with a first valve means 31 for opening and closing of the shunt itself.

[0026] The shunt flows into first inlet collector means 22 via a first pressure regulating valve 33 and via a second heat exchanger 35 with the refrigerating fluid of a second shunt connected to the first pipe immediately downstream of one of the first heat exchangers 28 and connected to the first inlet collector means 22 at least via a second pressure regulating valve 37 and through the second heat exchanger 35. Such pressure regulating valves 33, 37 are remotely operated by the control means and cause a controlled pressure drop in the fluid that crosses them.

[0027] The second exchanger 35 is of in countercurrent at two ways type, a first way is placed in series to the first shunt and the second way is placed in series to the second shunt obtaining the heat exchange between the fluid that runs through the first shunt and the fluid which runs along the second shunt.

[0028] The first pipe further comprises, downstream of one of the first heat exchangers 29 a connecting portion to the outputs of the second heat exchanger 35. Such a connecting portion that can be traveled by the refrigerating fluid, comprises a third pressure regulating valve 38, a third exchanger 39 assigned in a condition of flow of the refrigerating fluid along said portion of the first pipe to yield to the refrigerating fluid the heat of a secondary fluid cooling the latter, and second closing valve means 41 for end closing the portion or for the one way flow of the fluid.

[0029] The secondary fluid may consist of water or air

that are cooled and that are used for the summer air conditioning of a user.

[0030] The control means for the programmed actuation of said compressors 20, shunt means 26, 27, valve means 31, 41, regulating valves 33, 37, 38 and of each active element of the plant, are also connected to sensors of the state such as pressure, speed and temperature of the refrigerating fluid at various points of the installation, in particular upstream of the compressors 20.

[0031] Such control means are programmable to make various operations of the plant, in particular to switch the plant between a first and a second operation.

[0032] In the first operation, the shunt means 26, 27 and the first valve means 31 are actuated by the control means for the transit of the compressed refrigerating fluid from the first set P of the compressors 20 through at least one of the first heat exchangers 28, through at least the both first 33 and second 37 pressure regulator valves and through the both pipes of the second heat exchanger 35 until first inlet collector means 22.

[0033] In the second operation, the shunt means 26, 27 and the first valve means 31 are actuated so as to oblige the refrigerant fluid compressed by the first set P of the compressors 20 to pass through at least one of the first heat exchangers 28, 29, the third the pressure regulating valve 38, the third heat exchanger 39 and the second valve means 41 until to the first inlet collector means 22.

[0034] In the first operation, the fluid consisting in this example in carbon dioxide, takes at the inlet of the set P of compressors 20, namely into the first inlet collector means 22, a gaseous state or superheated vapor indicated by point 1c very close to the state change of the curve of the pressure - enthalpy diagram of Figure 1. As a result of the action of the compressors of the first set P the fluid reaches the point 2c or 2CA in a further embodiment of the plant discussed hereafter in which enthalpy, pressure and temperature are increased in respect to the point 1c. The fraction of fluid that runs through the first shunt undergoes, for effect of the first pressure regulating valve 33, a pressure drop reaching the point 1d and undergoes, due to the heat effect that yields to the remaining fraction of fluid in the second exchanger 35 and for the rejoining with such fraction downstream of this heat exchanger, an enthalpy decrease until the point 1c. The remaining fraction of the fluid crossing one or more of the first heat exchanger 28 in which it yield heat for the heating of users, it loses enthalpy and reaches the point 4a; subsequently through the second pressure regulating valve 37 undergoes a pressure drop reaching the point 2d and through the second heat exchanger 35 and with the subsequent rejoining with the fraction of the fluid of the first shunt obtains an enthalpy increase to the point 1c closing the cycle that, it is important to observe, it has provided heat to one or more users, without the need to yield frigories to the outside and optimizing the performance. The solution focused on the second heat exchanger 35, allows to achieve the object of provide

heating without heat exchange with the external environment, with temperatures of the environment of placement of the first exchanger 29 that also exceeds 32° C, using any refrigerator fluid also included carbon dioxide.

[0035] In the second operation, the fluid is not divided into two fractions and, after passing from the 1c to 2c point due to the compressors 20 of the first set P, passes through the first heat exchanger 29, consisting for example in a condenser or in an exchanger for the heating of a secondary fluid for feeding an user to be heated, where it yields heat and condenses reaching the point 5a. The subsequent passage through the third pressure regulating valve 38 causes a pressure drop of the refrigerating fluid until the point 6a to which physical state enters in the third heat exchanger 39 where it receives heat from a secondary fluid which is cooled and used, for example, for the summer air conditioning of a user consisting for example in a business premises; following the enthalpy increase reached at the outlet of the third heat exchanger 39, the refrigerating fluid returns to the vapor state of the point 1c or 3c and can enter in the compressors closing the cycle.

[0036] The plant also comprises a second set TN of compressors 42 (in a number equal to or greater than one) the outputs of which are connected to the first outlet collector means 24 and the inputs of which for the refrigerating fluid of the plant are connected to a common second inlet collector means 44. As clarified below, the compressors 20, 42 of the two groups can be grouped into a single group or exchanged of role or position in the circuit.

[0037] The common second inlet collector means 44 is fed with the refrigerating fluid by a second pipe having a connection means 45 which connects it to the first pipe downstream of the first heat exchanger 29 and upstream of the third pressure regulating valve 38.

[0038] From such connection means 45, the second pipe has a first pressure regulator means 47, passes through a first way of a fourth exchanger 49 and it flows into a receiver - separator means 51 from which exits by the lower outlet from the cooling fluid to the liquid state and continues to feed a set of users 53, 54 at normal temperature and/or at low temperature crossing them to flow into the second inlet collector means 44.

[0039] The users 53, 54 are equipped with respective exclusion valves and can be of the type with direct exchange evaporator, for example, for the cooling of cold store or of countercurrent exchanger type to cool a secondary fluid of the user.

[0040] The receiver - separator means 51 is equipped with a higher outlet for the steam, or for the refrigerating fluid in the gaseous state; this outlet is connected to the second inlet collector means 44 through a second pressure regulator means 56 and through the second way of the fourth heat exchanger 49. The second pressure regulator means 56 and the fourth exchanger 49 allow to bring the cooling fluid respectively to the pressure and to the correct temperature for the suction from the compressors 42 of the second set TN.

[0041] Each pressure regulator means 47, 56 comprises two pressure regulating valves, with outlets in mutual flow communication and with inlets connected to respective outlets of a shunt means actuated by the control means to switch the flow through a pressure regulator valve when a set of sensors of the pressure regulator means 47, 56 provide to the control means data indicating a malfunction of the other pressure regulating valve. In other words, in normal conditions the flow of refrigerating fluid passes through the lower main pressure regulator valve HPV1.A in the figures, in case of failure of the main valve detected by the control means on the basis of the pressures and temperatures generated, the flow is automatically switched to the auxiliary pressure regulating valve to maintain always activated the refrigeration.

[0042] Downstream of the connection means 45 and upstream of the first pressure regulator means 47, the second pipe passes through a first way of a fifth heat exchanger 58. An outlet for the vapor of the receiver - separator means 51 is connected to respective shunt means 60 actuated by the control means to connect said outlet to the second valve means 41, and then to the first inlet collector means 22 of the compressors 20 of the first set P, directly or through the second way of the fifth heat exchanger 58.

[0043] The fifth heat exchanger 58, inserted in the respective direct flash gas circuit at the inlet of the compressors 20 of the first set P by the control means through the actuation of the shunt means 60, it allows to obtain the correct flash gas temperature aspirated from such compressors 20.

[0044] The second pipe, downstream of the outlet for the liquid of the receiver - separator means 51 and upstream of the set of users 53, 54, passes through a first way of a sixth heat exchanger 62, the outlet of said first way is also connected, through a fourth pressure regulating valve 64 and the second way of the sixth heat exchanger 62, to the second inlet collector means 44 of the compressor 42 of the second set TN.

[0045] Such a configuration of the sixth heat exchanger 62 allows to supply the users at normal temperature 53 and at low temperature 54 with the refrigerating fluid in the state of saturated liquid free of gas bubbles.

[0046] The outlet of the first way of the sixth heat exchanger 62 is connected to the second inlet collector means 44 also by a fifth pressure regulating valve 66 actuated by the control means to adjust the outlet temperature of the refrigerating fluid from the compressors 42 of the second set TN reducing it by means of the reduction of the temperature at the inlet of such compressors.

[0047] The state of the refrigerating fluid in inlet into the compressor 42 of the second set TN is represented in the point 1a of the diagram of Figure 1.

[0048] The state of the refrigerating fluid in outlet from compressors 42 of the second set TN is represented in point 2a but, the mixing of the fluid in outlet from said compressors 42 and from the compressors 20 of the first

group P, which occurs in the first outlet collector means 24, the state of such fluids reaches the point 2ac. The fraction of the fluid that flows into the second pipe, in correspondence of the connection means 45, following the yield of heat in the first heat exchangers 28, 29 has lost enthalpy and its state is represented in the point 5a of the diagram of Figure 1. That fraction of the fluid of the second pipe, following to the transit in the fourth heat exchanger 49, of the lower outlet for the liquid of the receiver - separator means 51 and of the transit via the sixth heat exchanger 62, undergoes further cooling reaching the state shown in the diagram in 9a in which it can feed the users at normal temperature 53 and low temperature 54. The fraction of the refrigerating fluid that comes out from the users at normal temperature 53 has undergone an expansion with a pressure drop reaching the point 10a of the diagram and it has received heat from such users, with consequent increase in enthalpy which brings said fraction of fluid, in inlet to the compressor 42 of the second group TN, to the state represented at point 11a - 1a of the diagram.

[0049] The outlet for the refrigerating fluid at low temperature 54 of the user is connected to the second inlet connector means 44 via a third set BT of low temperature parallel compressors 70 (in a number equal to or greater than one) and a possible sixth heat exchanger 72 for optional cooling of the refrigerating fluid.

[0050] The fraction of the refrigerating fluid coming out from the users at low temperature 54 experienced an expansion and a heat input greater than those caused by the users at normal temperature and consequently such fraction of fluid reaches before the states 4b and after the state 1b of the diagram. The fraction of fluid in outlet from the users at low temperature enters in the low temperature compressor 70 of the third set BT coming out thereof, with increased pressure and enthalpy, in a state shown in 2b of the diagram with which enters in the sixth heat exchanger 72 where it is cooled, reaching the state, represented in the diagram in 1a, in which it can be reenter in the compressors 42 of the second set TN completing the cycle.

[0051] The plant can also comprise valve and/or hydraulic means to connect, in permanent or selectable manner, the second valve means 41 and/or the outlets of the set of users 53, 54 to the first inlet collector means 22 and/or to the second inlet connector means 44 and/or for the mutual connection of such first inlet collector means 22, 44.

[0052] Must be noted that in the switching between an inactive condition to an active condition and vice versa the positioning of the second valve means 41 downstream of the connecting portion of the first pipe provides the advantage of reducing the stresses and to reduce the switching timing in the passage from a condition to the other.

Claims

1. Refrigeration plant for refrigeration and air conditioning comprising at least a first set (P) of compressors (20) whose inlets for the plant refrigerating fluid are connected to a common first inlet collector means (22) and whose outlets are connected to a common first outlet collector means (24) connected to a first pipe provided with a set of shunt means (26, 27) for the refrigerating fluid each one assigned to insert or isolate from said first pipe a respective first heat exchanger (28, 29) assigned, in the state of insertion along the first pipe, to transfer to a secondary fluid the heat of the refrigerating fluid cooling or condensing the latter; said first pipe is also provided with a first branch having a first valve means (31) for opening and closing the first branch that is connected to the first pipe between the first outlet collector means (24) and the shunt means (26, 27); the first branch is connected to the first inlet collector means (22) by a first pressure regulating valve (33) and a first way of a second heat exchanger (35) with the refrigerating fluid of a second branch connected to the first pipe closely downstream to one of the first heat exchangers (28) and connected to the first inlet collector means (22) through a second pressure regulating valve (37) and through the second way of the second heat exchanger (35); said first pipe further comprises, downstream to one of the first heat exchangers (29), a connecting portion connected to the outlets of the second heat exchanger (35), and said first pipe further comprises a second closing valve means (41) for end closing the portion or for the one way flow of the fluid and it comprises a third pressure regulating valve (38) and, downstream to the latter (38), a third exchanger (39) assigned, in a flow condition of the refrigerating fluid along the said portion of the first pipe, to transfer heat from a secondary fluid to the refrigerating fluid cooling the secondary fluid; said plant is **characterized in that** the second closing valve means (41) is downstream to said third exchanger (39) and **in that** said plant further comprises control means for a programmed actuation of said compressors (20), shunt means (26, 27), valve means (31, 41), regulating valve (33, 37, 38) and each of the active element of the plant; said control means being programmed at least for a first operation in which the shunt means (26, 27) and the first valve means (31) allow the flow of the refrigerating fluid compressed by the first set (P) of compressors (20) through at least one of the first heat exchanger (28), through both the first and second pressure regulating valves (33, 37) and both ways of the second heat exchanger (35) to the first inlet collector means (22) and for a second operation in which the shunt means (26, 27) and the first valve means (31) route the refrigerating fluid compressed by the first set (P) of compressors (20) to transit through at least one

of the first heat exchangers (28, 29), the third pressure regulating valve (38), the third exchanger (39) and the second valve means (41) up to the first inlet collector means (22); said plant further comprises a second set (TN) of compressors (42) whose outlets are connected to the first outlet collector means (24) and whose inlet for the plant refrigerating fluid are connected to a common second inlet collector means (44) fed by the refrigerating fluid by a second pipe having a connection means (45) that connects it to the first pipe downstream to the first heat exchanger (29) and upstream to the third pressure regulating valve (38); from said connection means (45) the second pipe has a first pressure regulator means (47), it passes through a first way of a fourth exchanger (49) and it flows into a receiver - separator means (51) from which it outflows from the outlet for the refrigerating fluid in the liquid state and it proceeds to feed a set of users (53, 54) at normal temperature and/or low temperature flowing through them then it flows in the second inlet connector means (44); an outlet for the steam of the receiver - separator means (51) is connected to the second inlet connector means (44) through a second pressure regulator means (56) and the second way of the fourth exchanger (49); downstream to the connection means (45) and upstream to the first pressure regulator means (47), the second pipe passes through a first way of a fifth exchanger (58); an outlet for the steam of the receiver - separator means (51) is connected to respective shunt means (60) actuated by the control means to connect said outlet to the second valve means (41) directly or through the second way of the fifth exchanger (58).

2. Plant according to claim 1 **characterized in that** each pressure regulator means (47, 56) comprises two pressure regulating valves, having the outlets in mutual flow communication and with the inlets connected to respective outlets of a shunt means actuated by control means to switch the flow through a pressure regulating valve when a set of sensors of the pressure regulator means (47, 56) provide to the control means data that indicate a malfunction of the other pressure regulating valve.

3. Plant according to claim 1 or 2 **characterized in that** the second pipe, downstream the outlet for the liquid of the receiver - separator means (51) and upstream of the users set (53, 54), passes through a first way of a sixth exchanger (62); the outlet of said first way is also connected, through a fourth pressure regulating valve (64) and the second way of the sixth exchanger (62), to the second inlet collector means (44).

4. Plant according to claim 3 **characterized in that** the outlet of the first way of the sixth exchanger (62) is

connected to the second inlet connector means (44) through a fifth pressure regulating valve (66) actuated by the control means to adjust the outlet temperature of the refrigerating fluid from the compressors (20, 42) of the first (P) and/or second (TN) sets reducing it.

5. Plant according to any claims from 2 to 4 **characterized in that** the outlet for the refrigerating fluid of a user at a low temperature (54) is connected to the second inlet collector means (44) through a set (BT) of parallel low temperature compressors (70) and through a possible optional sixth heat exchanger (72) for cooling the refrigerating fluid.
6. Plant according to any claims from 2 to 5 **characterized in that** it comprises valve and/or hydraulic means to connect the second valve means (41) and/or the outlets of the set of users (53, 54) to the first inlet collector means (22) and/or to the second inlet collector means (44) and/or to carry out the mutual connection of such collector means (22, 44).

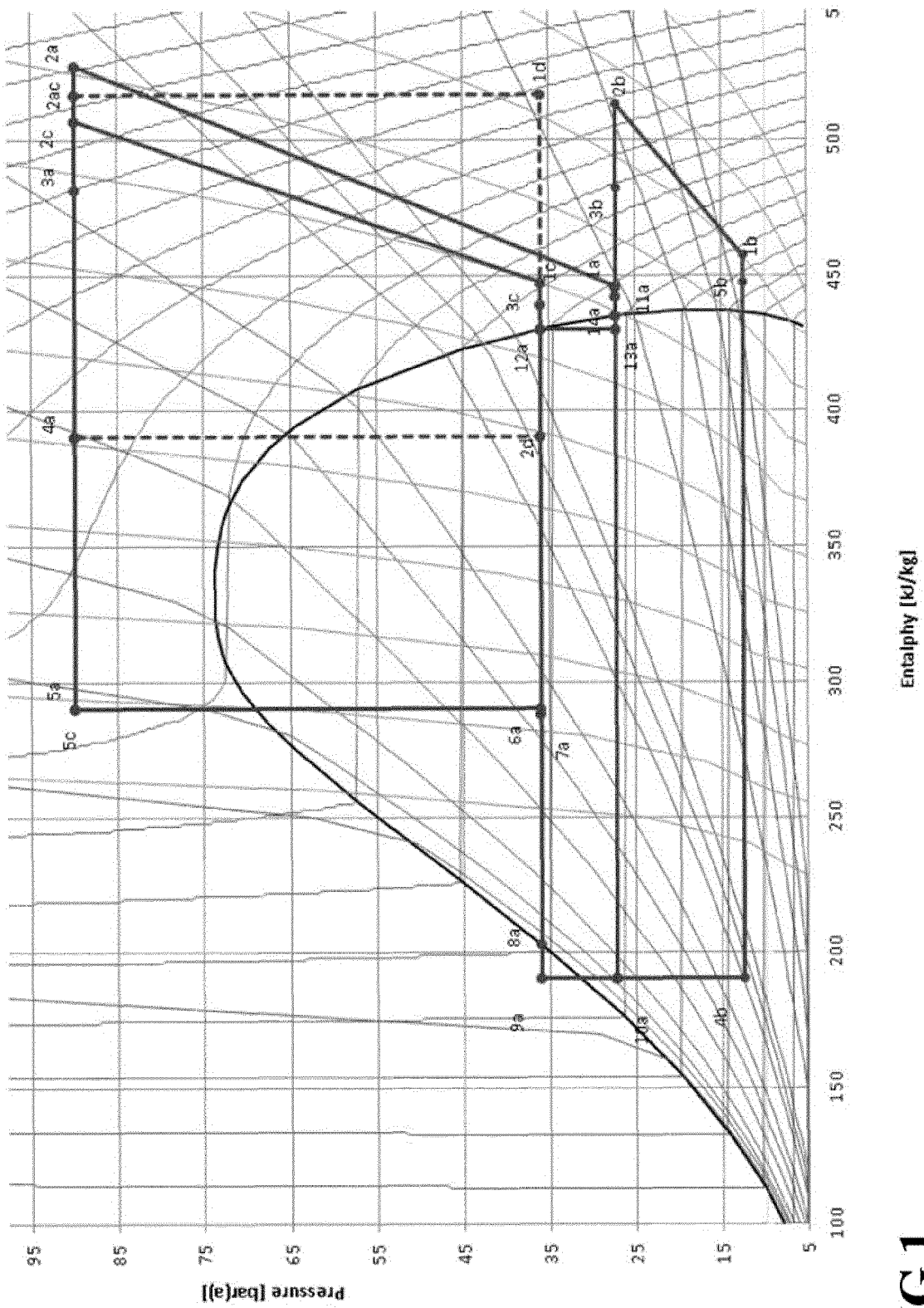


FIG.1

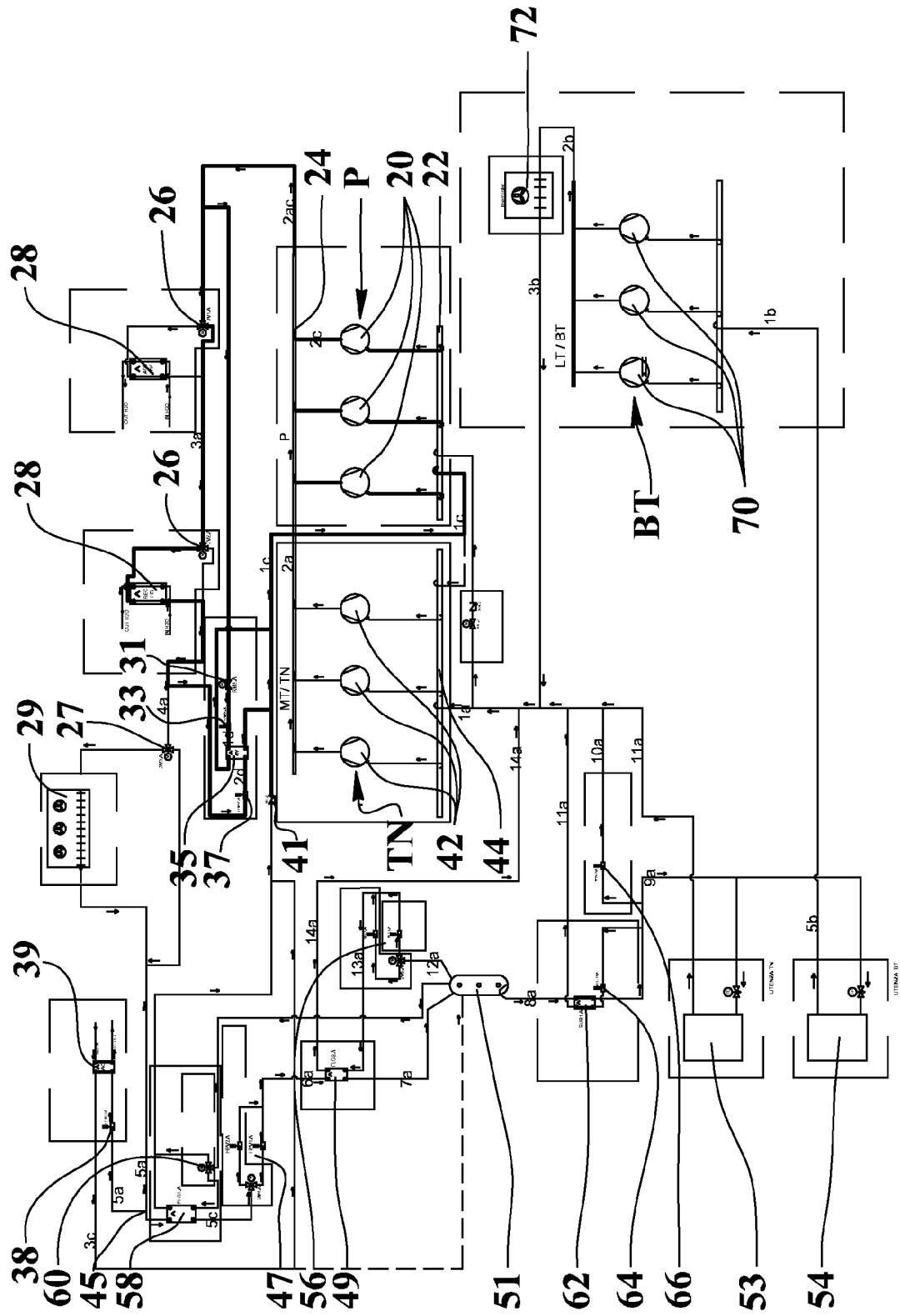
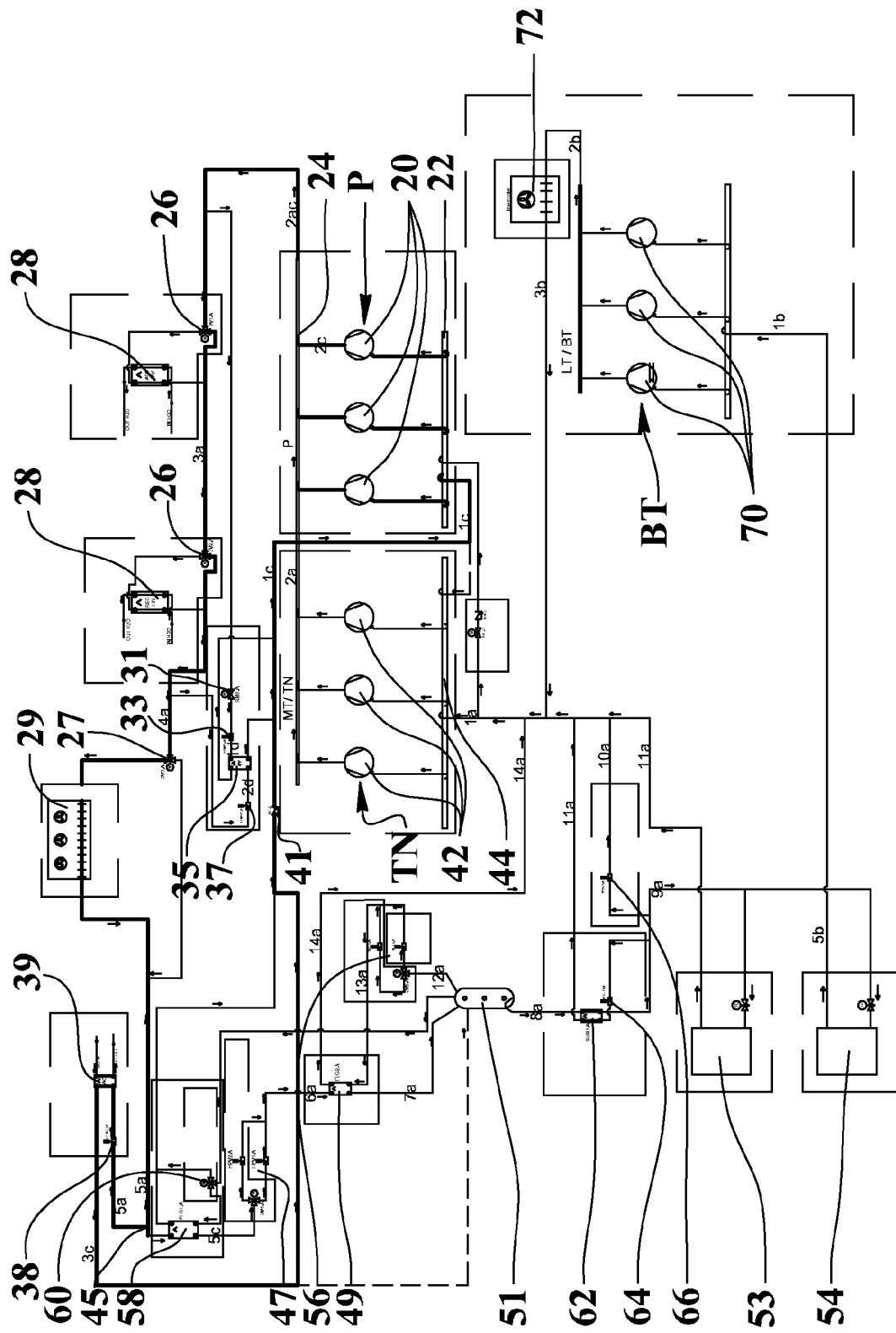


FIG.2





EUROPEAN SEARCH REPORT

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 EP 15 18 7860

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DOCUMENTS CONSIDERED TO BE RELEVANT			
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Place of search Munich		Date of completion of the search 27 January 2016	Examiner Szilagyi, Barnabas
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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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