(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 660 433 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
06.11.2013 Bulletin 2013/45

(51) Int Cl.:
F01K 25/04 *(2006.01)* ***F01K 25/10*** *(2006.01)*

(21) Application number: **13166091.2**

(22) Date of filing: **30.04.2013**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME

(30) Priority: **02.05.2012 IT AN20120049**

(71) Applicant: **E-Mind Studi e Progettazione Ing. Vitri Giuseppe e Ing. Luchetti Filippo**
61020 Sant'Angelo in Lizzola (PU) (IT)

(72) Inventor: **Vitri, Giuseppe**
I-61020 Montecalvo in Foglia (PU) (IT)

(74) Representative: **Negrini, Elena**
Agazzani & Associati S.r.l.
Via dell'Angelo Custode 11/6
40141 Bologna (IT)

(54) Device and method for electric power generation

(57) An electric power generation device comprising at least a first tank (2) and a second tank (3) for an operating fluid, provided respectively with a first connection means (7) having a respective opening and closing valve and a second connecting means (17) connecting the first (2) and second (3) tanks respectively to an input and an output of a motor means (5) operable by the operating fluid of the device (1); said first tank (2) is associated with a first heat exchanger means (8) powered by a respective circuit (8a, 8b) supplied on command from a first thermal fluid heated by a first heat source and is assigned to heat through the first heat exchanger means (8) the operating fluid contained in the first tank (2) yielding to it the heat taken from said first source.

Said device (1) comprise at least a first opening and closing means (4) equipped with a respective opening and closing valve and connected to the first (2) and second (3) tanks to connect and separate the inner volumes where, starting from an initial equilibrium condition of the operating fluid of the two tanks (2, 3), the valves of the at least a first opening and closing means (4) and the first connecting means (7) are in the closed condition separating the operating fluid of the tanks and is controlled the flow of the first thermal fluid, heated to a temperature higher than the equilibrium one of the operating fluid, in the first heat exchanger means (8) raising the temperature of the operating fluid in the first tank and thereby raising the pressure to values higher than the equilibrium pressure and higher than the pressure of the operating fluid of the second tank (3) until reaching a predetermined temperature or pressure value at the achievement of which it is controlled the valve opening of the first connecting means (7) allowing the operating fluid of the first tank (2) to flow in the second tank (3) through the first (7) and second (17) connecting means and through the motor means (5) actuating it for the operation of a connected electric generator (6) or other users until the pressure difference between the two tanks reaches or falls below a predetermined value at which it is stopped the first fluid flow in the first heat exchanger means (8) and controlled the opening of the first opening and closing means (4) valve until reaching the equilibrium condition of the operating fluid of the two tanks (2, 3).

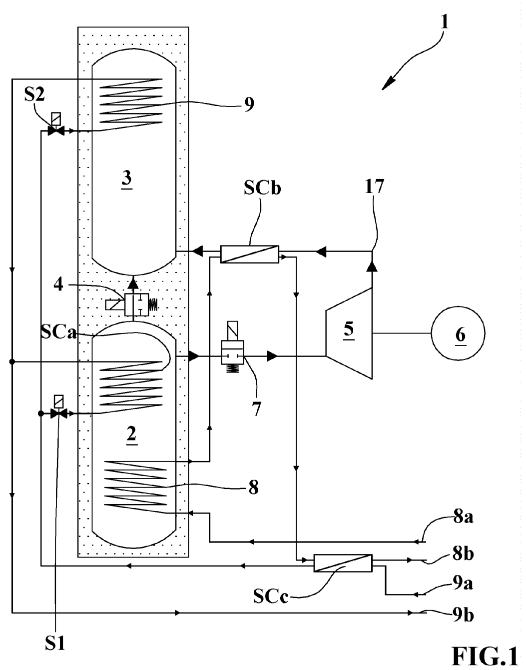

FIG.1

EP 2 660 433 A1

Description

[0001] The present invention relates to the field concerning the energy transformation and in particular it relates to a device for electric power generation suitable to exploit thermal jumps of reduced size, but not only, and that can also be used in different environments such as domestic, commercial, industrial and assigned for communities.

[0002] Said invention also relates to a method for electric power generation wherein the meaning of "electric power generation" is the transformation of thermal energy into mechanical energy suitable for operating an electric power generator, for example an alternator or similar or for operating other types of users.

[0003] Document EP1801364A1 discloses to a heat pump for feeding a refrigerant without using a mechanical pump, a heat pump system, and a transcritical Rankine cycle system, the heat pump having a function to feed a refrigerant by vaporizing a liquid refrigerant liquefied in a condenser by a heat source outside the system or by utilizing a part of heat used to operate the system and raising pressure of the vaporized refrigerant, the heat pump system comprising a plurality of the heat pumps, the transcritical Rankine cycle system comprising the heat pump or the heat pump system. The invention is suitably applied to a transcritical Rankine cycle, etc. without need for a mechanical pump which induces mechanical loss in feeding working refrigerant.

[0004] Document DE10126403A1 discloses a power station having carbon dioxide fluid as its working means, a forward line with at least one turbine or piston engine and a return line with at least one pressure build-up device. The forward line and the return line realize a closed liquid circuit. The station has a high pressure container and a low pressure container, each divided by an inner floating partition wall in a liquid carbon dioxide space and a nitrogen space. The liquid carbon dioxide space of the high and low pressure containers have respective constant temperature controller. The turbine in the forward line from the high to the low pressure container and the pressure build-up device in the low pressure line from the low to the high pressure container.

[0005] Document DE102009057179 discloses to an engine which consists of an evaporator vessel or working cylinder and a fluid turbine where additionally suitable control mechanisms are used by significantly increase efficiency. The vapor is used to pressurize the feeding turbine liquid.

[0006] Document DE3624357 discloses a method for obtaining energy from the ambient air where a liquid operated turbine is fed by pressurized liquid stored in a pressure vessel provided with a piston having a weight resting onto it to keep the liquid into the pressure vessel under pressure while said liquid is fed into the pressure vessel by a static pump operated by the environment temperature changes. Several liquids as water, glycol and alcohol are used.

[0007] Document DE102005049215 discloses a method and device for generating mechanical or electrical energy from heat where a refrigerant circuit provides heat from a geothermal probe to an operative circuit through a set of heat exchanger. The operative circuit includes a turbine operated by a fluid heated by the refrigerant circuit and by compression heat produced by compressors of the operative circuit the same. A turbine replaces a throttling valve o thermal expansion valve.

[0008] The above mentioned prior art presents the disadvantages consisting in their complexity and, sometimes, in their elevate costs and inadequate reliability.

[0009] Another disadvantage of certain known solutions consists in the requirements of fluids and operating conditions, in particular temperature, involving state changes, from gaseous to liquid and vice versa, of the fluid itself with consequent operating limitations.

[0010] An object of the present invention is to propose an electric or mechanical power generation device and to propose a method for electric power generation that are simple, cheap and reliable.

[0011] Another object is to propose a device of reduced size and modular used individually or in multiple copies interconnected to obtain a continuous supply of power.

[0012] Further object is to propose a device and a method feasible and operable with fluids of almost any nature, both in conditions of phase transition and without any transitions of phase.

[0013] Another object is to propose a device suitable to exploit thermal sources with relatively low temperatures also negative, for example at -10°C, and thermal sources having very small temperature differences, for example also of only 10°C.

[0014] Further object is to propose a device suitable for domestic use, for applications in environments such as industrial, livestock breeding, agriculture, renewable energy generation, and everywhere thermal sources are available even having low enthalpy.

[0015] The characteristics of the invention are highlighted in the following with particular reference to the accompanying drawings wherein:

- Figure 1 shows a schematic view of the electric power generation device of the present invention associated with a motor means connected to a generator means;
- Figures 2 to 5 show schematic views of respective variants of the device of Figure 1;
- Figure 6 shows an operating cycle diagram of the device according to the method of the invention wherein the abscissa axis refers to the enthalpy, the ordinate axis refers to the pressure and wherein the curves with arrows indicate the trend of the fluid state inside the tanks and lines, with respective directions and ways, indicate the cycle points of the system process fluid.

[0016] With reference to figure 1, numeral 1 indicates the electric power generation device, object of the present invention, comprising a first tank 2 and a second tank 3 for an operating fluid. These tanks can be made of steel, aluminum alloys, synthetic materials and composites, such as carbon, aramide, and/or glass or the like fibers, bonded in a resin matrix and are suitable to withstand the pressures and the provided pressure variation cycles, that can range from dozen of kg/cm^2 to hundreds of kg/cm^2. Said tanks can have any form, generally cylindrical and they are preferably stacked arranged, with the first tank 2 below the second tank 3. The device 1 comprises a first opening and closing means 4, for example of tubular type and equipped with a respective remotely operated opening and closing valve. The first opening and closing means 4 is connected to the upper portion of the first tank 2 and to the lower portion of the second tank 3 to connect or separate the inner volumes.

[0017] The first tank 2 is provided with a first connecting means 7 having a respective remote controlled opening and closing valve connecting or separating the inner volume of said first tank 2 with the input of a motor means 5, for example consisting of a turbine or a micro-turbine of gas expansion or steam or biphasic mixture in another apparatus converting pressure energy in mechanical energy or for the direct exploitation of the pressure energy. The second tank 3 is provided with a second tubular connecting means 17 which puts said second tank 3 in flow communication with the expanded fluid outlet of the motor means 5.

[0018] The first tank 2 contains a first heat exchanger means 8, for example tubular kind exchanger, fed by a respective circuit 8a, 8b wherein a first thermal fluid circulates, thanks to a pump, of remotely controlled blower or compressor or similar type, the fluid is heated by a first thermal source and it is assigned to heat, by means of the first heat exchanger 8, the operating fluid contained in the first tank 2 yielding to it the heat taken from said first source. This first source may consist, for example, in a solar collector, in a condenser of a refrigeration system or an air conditioner, or in a duct for hot water exhausted and derived from an industrial process or from households, or from any other source also marginal or wasted.

[0019] The second tanks 3 contains a second heat exchanger means 9 tubular fed by a respective circuit 9a, 9b wherein a second thermal fluid circulates, thanks to a respective pump, of remotely controlled blower or compressor or similar respective type, the second thermal fluid is cooled by a second heat source having a lower temperature in respect to the first heat source and/or to the environment temperature. This second thermal fluid is assigned to cool by means of the second heat exchanger means 9 the operating fluid contained in the second tank 3 by withdrawing from it the heat that is transferred to said second source consisting of, for example, the evaporator of a refrigeration circuit, the external environment, the marine water below the thermocline, or any other source also marginal or wasted having temperature below the ambient temperature one or to a predetermined value.

[0020] Alternatively the device can be equipped with a single heat exchanger means of one tank while the other tank can be exposed directly to air and to ambient conditions. Preferably the device comprises both the above mentioned heat exchangers and the tanks are insulated for increase the heat insulation.

[0021] The invention provides that the embodiment of Figure 1 exploits first and second thermal fluids equal and consisting in a liquid, preferably water, but also it provides alternatives, described in the variants, and consisting for example of a phase transition fluid such as a refrigerating fluid or a gas such as air.

[0022] Optionally, to speed up a rebalancing phase of the device described in the following, the first tank may contain a third heat exchanger means SCa inside the first tank 2 and connected in shunt to the circuit 9a, 9b feeding the second heat exchanger means 9 where such a circuit is provided of valves S2, S1 for the selective exclusion of the second 9 and the third SCa heat exchanger means.

[0023] The device also comprises temperature and/or pressure sensors associated, for example, to tanks, to circuits 8a, 8b, 9a, 9b of the thermal fluid and/or to the first 7 and second 17 connecting means. These sensors are connected, for instance in electrical manner, to respective ports for the signals of control and management means of the device, for example of the microprocessor type, with memories, A/D and/or D/A interfaces , which remotely control and command valves, diverters, pumps and other active elements of the device based on a control and management program.

[0024] The invention provides that the operating fluid is of a type which in the operating conditions may undergo phase transitions or of a type which under such conditions remains at the gaseous phase. In particular, the invention provides that the operating fluid of the embodiment of Figure 1 consists of carbon dioxide.

[0025] Optionally the device may comprise first countercurrent or parallel heat exchanger means SCb having two distinct ducts and in mutual connection of the thermal flow. A first duct of the first countercurrent or parallel heat exchanger means SCb is inserted in series in the feeding circuit 8a, 8b of the heated first thermal fluid in the first heat exchanger means 8, downstream of the latter first exchanger means 8 with respect to the flow direction in said circuit 8a, 8b, and in this first duct.

[0026] The second duct is inserted in series in the second connecting means 17 downstream of the motor means 5.

[0027] Optionally the device may further comprise second countercurrent or parallel heat exchanger means SCc having two distinct ducts and in connection to the thermal flow. The first duct is inserted in series in the circuit 9a, 9b feeding the cooled second fluid to the second heat exchanger means 9 downstream of the latter second heat exchanger means 9 and the second duct is inserted in series in the second connecting means 17 downstream motor means 5.

[0028] The second countercurrent or parallel heat exchanger means SCc is placed downstream the first countercurrent or parallel heat exchanger means SCb.

[0029] These heat countercurrent or parallel heat exchanger means SCb, SCc don't directly improve the efficiency because they are used mainly to keep stable the system.

[0030] The operation of the device 1 provides, starting from an initial condition of thermal and pressure equilibrium of the operating fluid of the two tanks 2, 3, that the control means operates the closing of the valves of the first opening and closing means 4 and of the first connecting means 7 thereby separating the portions of the operating fluid in the two tanks.

[0031] Immediately after the valves closing, the control means operates the flows of hot and cold thermal fluid, heated and cooled to temperatures respectively higher and lower than the balance temperature of the operating fluid, in the first 8 and second 9 heat exchanger means through the actuation of respective circulation pumps.

[0032] Consequently the temperature and the pressure of the operating fluid in the first tank increase and the temperature and the pressure of the operating fluid in the second tank decrease with respect to temperature and pressure of equilibrium up to reaching a predetermined temperature or pressure difference between the two tanks.

[0033] Upon reaching the predetermined difference the control means operate the opening of the valve of the first connecting means 7 allowing the operating fluid of the first tank 2 to flow in the second tank 3 through the first 7 and second 17 connecting means and through the motor means 5 operating the latter.

[0034] The motor means 5 can rotate the electric power generator 6 connected to it, or another user, until the pressure difference between the two tanks reaches or falls below a predetermined value at which the control means operate the stop of the flows of hot and cold fluid in the first 8 and second 9 heat exchanger means, the control means operate also the opening of the first opening and closing means 4 until reaching the equilibrium condition of the operating fluid of the two tanks 2, 3 possibly speeding up by means of the third heat exchanger means SCa.

[0035] As an example of operation, considering the embodiment of the device of Figure 1 without the two optional countercurrent or parallel heat exchanger means and having two tanks of 30 liters each, filled with 22kg of total CO_2 where the upper tank is maintained at constant temperature of 31°C using, for example, ambient temperature at maximum of 26°C and the lower tank at a temperature of 55°C by means of, for example, water at 60°C coming from a solar collector, it is achieved a maximum difference in pressure of 32bar, a maximum power of 940W, an average power of 670W and an efficiency of 8% considering as efficiency the electrical or mechanical energy obtained divided by the energy used to keep hot the lower tank.

[0036] One of the possible operations of the device above mentioned is diagrammatically shown in Figure 6 where:

- the point A represents the heating end point of the first tank 2 hot lower wherein the fluid contained in it reaches maximum pressure;
- the point B represents the point of thermal and pressure equilibrium of the fluid contained in the two tanks 2, 3;
- the curve C represents the evolution of the state of the fluid of the first tank 2 lower hot during the motor means operation;
- the curve D represents the evolution of the state of the fluid of the second tank 3 upper cold during the motor means operation;
- the points CE and DE represent the expansion end points of the fluid in which the pressure of the first 2 and second 3 tanks is equal;
- the line E represents the heating isochoric transformation of the first tank 2 lower;
- line F represents the curve of the first expansion of the fluid in the motor means 5, for example in a turbine or similar;
- line G represents the i-th curve of the i-th expansion in the motor means 5.

[0037] The variant of Figure 2 differs from the embodiment of Figure 1 in that the first heat exchanger means 8 and the respective circuit 8a, 8b and the second heat exchanger means 9 and the respective circuit 9a, 9b use as thermal fluids gas type fluids, for example two identical thermal fluids consisting of air.

[0038] The hot and cold air flows of respectively the first 8 and second 9 exchanger means are operated by respective blowers of the two circuits 8a, 8b, 9a, 9b controlled by the control means.

[0039] The variant of figure 3 differs from the embodiment of Figure 1 in that the first heat exchanger means 8 and the respective circuit 8a, 8b are of hot air type while the second heat exchanger means 9, the third heat exchanger means SCa and their circuit 9a, 9b use water or other liquid.

[0040] The variant of figure 4 differs from the embodiment of Figure 1 in that it comprises a second opening and closing means 14, parallel to the first 4, equipped with a respective opening and closing valve and connected to the first 2 and second 3 tanks to connect and separate their inner volume.

[0041] This second opening and closing means 14 is assigned, in cooperation with the first opening and closing means 4, to achieve a movement, for example of natural type, of the operating fluid for speeding up the reaching of the equilibrium condition of the operating fluid.

[0042] Furthermore, the first 4 and/or second 14 opening and closing means can be equipped with a fan or pump means, applied in series to the respective valves. Such pump means establish a forced circulation of the operating fluid to further speed up the achievement of the equilibrium condition of the operating fluid.

[0043] The variant of Figure 5 refers to a coupled system and with appropriate recoveries.

[0044] In particular, this variant provides two copies of the device 1 connected together in parallel and to the same motor means 5. The control means operate and command the two copies or, in other word, two reproductions 1 with temporally offset phases for extended or continuous operation of the common motor means 5.

[0045] Each first tank 2 is internally provided with a respective fourth recovery exchanger means 19 whose input is connected via a diverter valve 20 to the output of the common motor means 5 and whose output is connected to a first tank 3 and to the other adjacent copy of the device 1. The invention provides that the number of specimens connected in parallel can be greater than two.

[0046] At the same above conditions for the device of Figure 1, the variant of Figure 5 reaches maximum power of 805W, average power of 450W and efficiency of 25% considering as efficiency the electrical or mechanical energy obtained divided by the energy used to keep hot the coupled system only during the electric power or mechanical energy generation.

[0047] The electric power generation method object of the present invention comprises the following steps:

- containing a predetermined amount of an operating fluid in two tanks first 2 and second 3 mutually separable and connectable via a first closing and opening means 4 provided with a respective opening and closing valve, and by a motor means 5 whose input and output are connected to said tanks by means of connecting means 7, 17 provided with at least a respective opening and closing valve;
- starting from a thermal and pressure equilibrium condition of the operating fluid in the two tanks, separate the latter 2, 3 by means of the first opening and closing means 4;
- heating the operating fluid contained in the first tank 2 through a first heat exchanger 8 controlled supplied with a first thermal fluid heated by a first heat source;
- optionally cooling the operating fluid contained in the second tank 3 via a second heat exchanger means 9 controlled supplied with a second thermal fluid cooled by a second heat source;
- the achievement of a predetermined temperature or pressure difference between the contents of the first 2 and second 3 tanks, putting in flow communication said tanks respectively with the input and the output of the motor means 5, actuating it, via the opening of the at least one valve of the first 7 and 17 seconds connecting means.

[0048] An advantage of the present invention is to provide an electric power or mechanical energy generation device and to propose a method for electric power generation that are simple, cheap and reliable.

[0049] Another advantage is to provide a device of reduced size and modular used individually or in multiple copies interconnected to obtain a continuous supply of power.

[0050] Further advantage is to provide a device and a method feasible and practicable with fluids of almost any nature, both in phase transition conditions both without any transitions.

[0051] Another advantage is to provide a device suitable to exploit thermal sources with relatively low temperatures and very small temperature differences, for example also of only 10°C.

[0052] Further advantage is to provide a device suitable for domestic use, for applications in environments such as industrial, livestock, agriculture, renewable energy generation, and everywhere sources are available even having low enthalpy.

Claims

1. Electric power generation device comprising at least a first tank (2) and a second tank (3) for an operating fluid, provided respectively with a first connection means (7) having a respective opening and closing valve and with a second connecting means (17) connecting the first (2) and second (3) tanks respectively to an input and an output of a motor means (5) operable by the operating fluid of the device (1); said first tank (2) is associated with a first heat exchanger means (8) fed on command by a respective circuit (8a, 8b) with a first thermal fluid heated by a first heat source, said fluid is assigned to heat through the first heat exchanger means (8) the operating fluid contained in the first tank (2) giving to it the heat taken from said first source; said device (1) is **characterized by** comprising at least one first opening and closing means (4) equipped with a respective opening and closing valve and connected to the first (2) and second (3) tanks to connect and separate the inner volumes thereof where, starting from an initial equilibrium condition of the operating fluid of the two tanks (2, 3), the valves of the at least one first opening and closing means (4) and of the first connecting means (7) are in the closed condition separating the operating fluid of the tanks and is activated the flow of the first thermal fluid, heated to a temperature higher than the equilibrium temperature of the operating fluid, in the first heat exchanger means (8) increasing the temperature of the operating fluid in the first tank and increasing the pressure thereof to values higher than the equilibrium pressure and higher than the pressure of the operating fluid of the second tank (3) until reaching a predetermined temperature or pressure value, at the achievement of said pre-

determined value it is operated the opening of the valve of the first connecting means (7) allowing the operating fluid of the first tank (2) to flow in the second tank (3) through the first (7) and second (17) connecting means and through the motor means (5) operating it for the actuation of a connected electric generator (6) or other users until the pressure difference between the two tanks reaches or falls below a predetermined value at which it is stopped the first fluid flow in the first heat exchanger means (8) and controlled the opening of the first opening and closing means (4) valve until reaching the equilibrium condition of the operating fluid of the two tanks (2, 3).

2. Device according to claim 1 **characterized by** comprising a second heat exchanger means (9) associated to the second tank (3) and fed on command by a respective circuit (9a, 9b) with a second thermal fluid cooled by a second heat source, said second fluid is assigned to cool through the second heat exchanger means (9) the operating fluid contained in the second tank (3) withdrawing from it the heat that is transferred to said second source.

3. Device according to any of the claims 1 or 2 **characterized in that** the operating fluid consists of a fluid that, at the operating conditions, may have phase transitions or it consists of a fluid that, at such conditions, remains in the gaseous phase.

4. Device according to any of the previous claims **characterized in that** the operating fluid is of type having a high pressure increase with respect to the energy supplied, having high pressure - enthalpy ratio and preferably it consists of carbon dioxide.

5. Device according to any of the claims 2 or 3 **characterized in that** the first and second thermal fluids can be different or equal and they can be chosen among a liquid, such as water, a phase transition fluid such as a refrigerant, a gas such as air.

6. Device according to the claim 2 and any of the previous claims **characterized by** comprising a third heat exchanger means (SCa) inside the first tank (2) and connected in shunt to the circuit (9a, 9b) for supplying the second heat exchanger means (9) where the circuit is provided with valves (S2, S1) for selective exclusion of the second (9) and the third (SCa) heat exchanger means.

7. Device according to any of the previous claims **characterized in that** it comprises first countercurrent or parallel heat exchanger means (SCb) having two distinct ducts in thermal flow connection where a first duct is inserted in series in the circuit (8a, 8b) for feeding the first thermal fluid heated in the first heat exchanger means (8) downstream of the latter first heat exchanger means (8) with respect to the flow direction into said circuit (8a, 8b) and into said first duct and where the second duct is inserted in series in the second connecting means (17) downstream the motor means (5).

8. Device according to any of the previous claims **characterized in that** it comprises second countercurrent or parallel heat exchanger means (SCc) having two distinct ducts in thermal flow connection where a first duct is inserted in series in the circuit (9a, 9b) for feeding the cooled second thermal fluid to the second heat exchanger means (9) downstream the latter second heat exchanger means (8) and where the second duct is inserted in series in the second connecting means (17) downstream the motor means (5).

9. Device according to claims 7 and 8 **characterized in that** the second countercurrent or parallel heat exchanger means (SCc) is placed downstream the first countercurrent or parallel heat exchanger means (SCb).

10. Device according to claim 5 **characterized in that** the circuit (8a, 8b) of the first heat exchanger means (8) and the circuit (9a, 9b) of the second heat exchanger means (9) are equipped with pumps or flow blowers of first and second thermal fluid respectively in case of liquid and gaseous thermal fluid.

11. Device according to any of the previous claims **characterized in that** it comprises a second opening and closing means (14) equipped with a respective opening and closing valve and connected to the first (2) and second (3) tanks to connect and separate the inner volumes thereof; such second opening and closing means (14) being assigned, in cooperation with the first opening and closing means (4), to achieve a circulation of the operating fluid for the speeding up of the achievement of the equilibrium condition of the operating fluid itself.

12. Device according to claim 11 **characterized by** comprising at least pumping means, such as pump or fan, applied in series to the first (4) and/or second (14) opening and closing means, these pumping means being assigned to achieve a forced circulation of the operating fluid to speed up the achievement of the equilibrium condition of the operating fluid itself.

13. Device according to any of the previous claims **characterized by** being connected in parallel to a plurality of reproductions of the device (1) preferably operated with temporally offset phases for extended or continuous operation of the motor means (5) that is common to the plurality of devices (1).

14. Device according to claim 13 **characterized in that** each first tank (2) is internally provided with a respective fourth heat exchanger means (19) whose input is connected via a diverter valve (20) to the output of the common motor means (5) and whose output is connected to a first tank (3) of an adjacent reproduction of the device (1).

15. Method for electric power generation by means of the device according to any of the previous claims **characterized by** comprising the steps of:

- containing a predetermined amount of an operating fluid into the first (2) and second (3) tanks mutually separable and connectable by means of at least one first closing and opening means (4), provided with a respective opening and closing valve, and by means of connecting means (7, 17), provided with at least a respective opening and closing valve, and by means of an interconnected motor means (5);
- starting from a condition of thermal and pressure equilibrium of the operating fluid in the two tanks, separating these last two (2, 3) by closing the valve of the first closing and opening means (4);
- heating the operating fluid contained in the first tank (2) by means of a first heat exchanger (8) fed on command with a first thermal fluid heated by a first heat source;
- optionally cooling the operating fluid contained in the second tank (3) by means of a second heat exchanger means (9) fed on command with a second thermal fluid cooled by a second heat source;
- at the achievement of a predetermined temperature or pressure difference between the contents of the first (2) and second (3) tanks, putting in flow communication such tanks respectively with an input and an output of the motor means (5), actuating it, by means of the first (7) and second (17) connecting means controlling the opening of the at least one respective opening and closing valves.

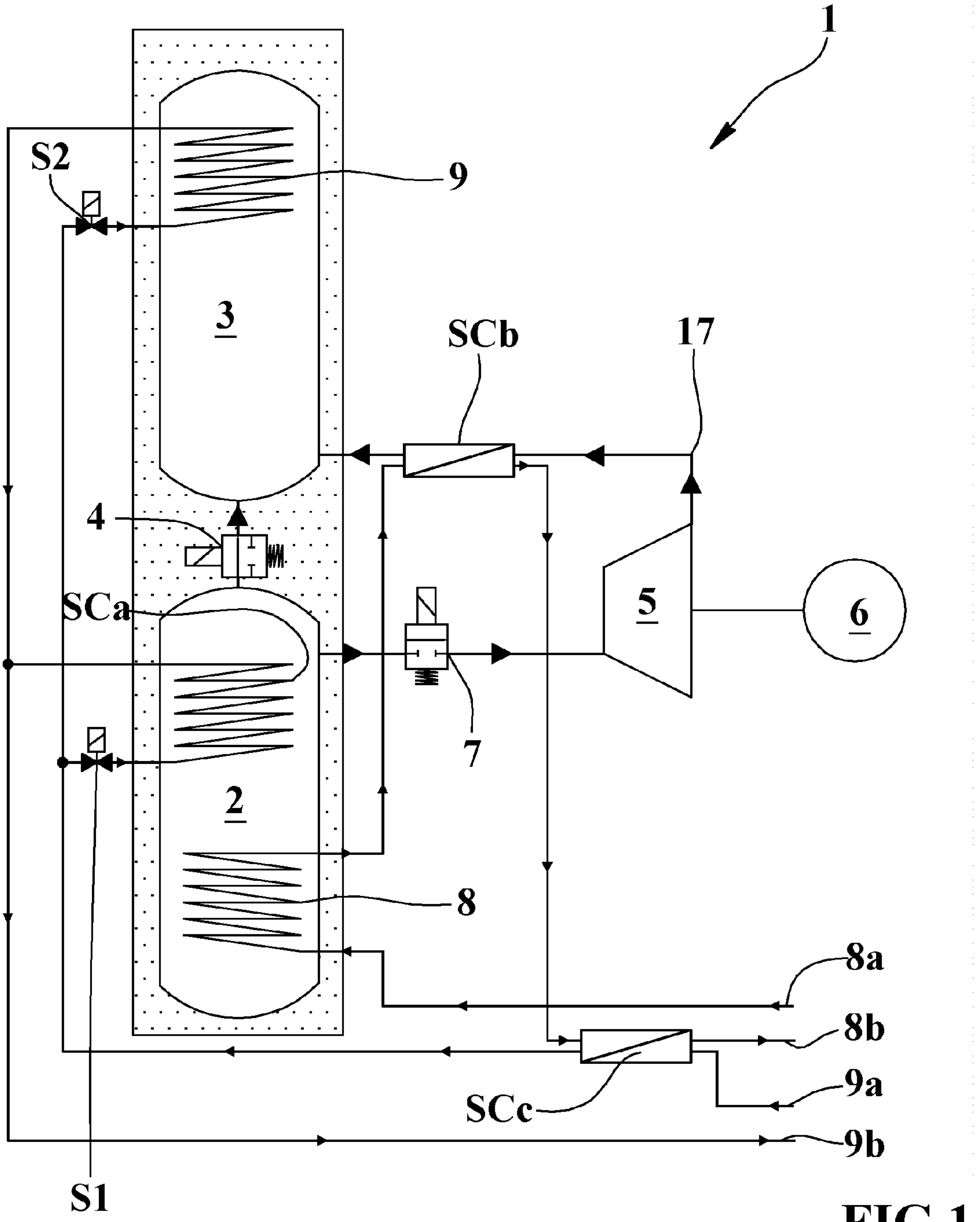

FIG.1

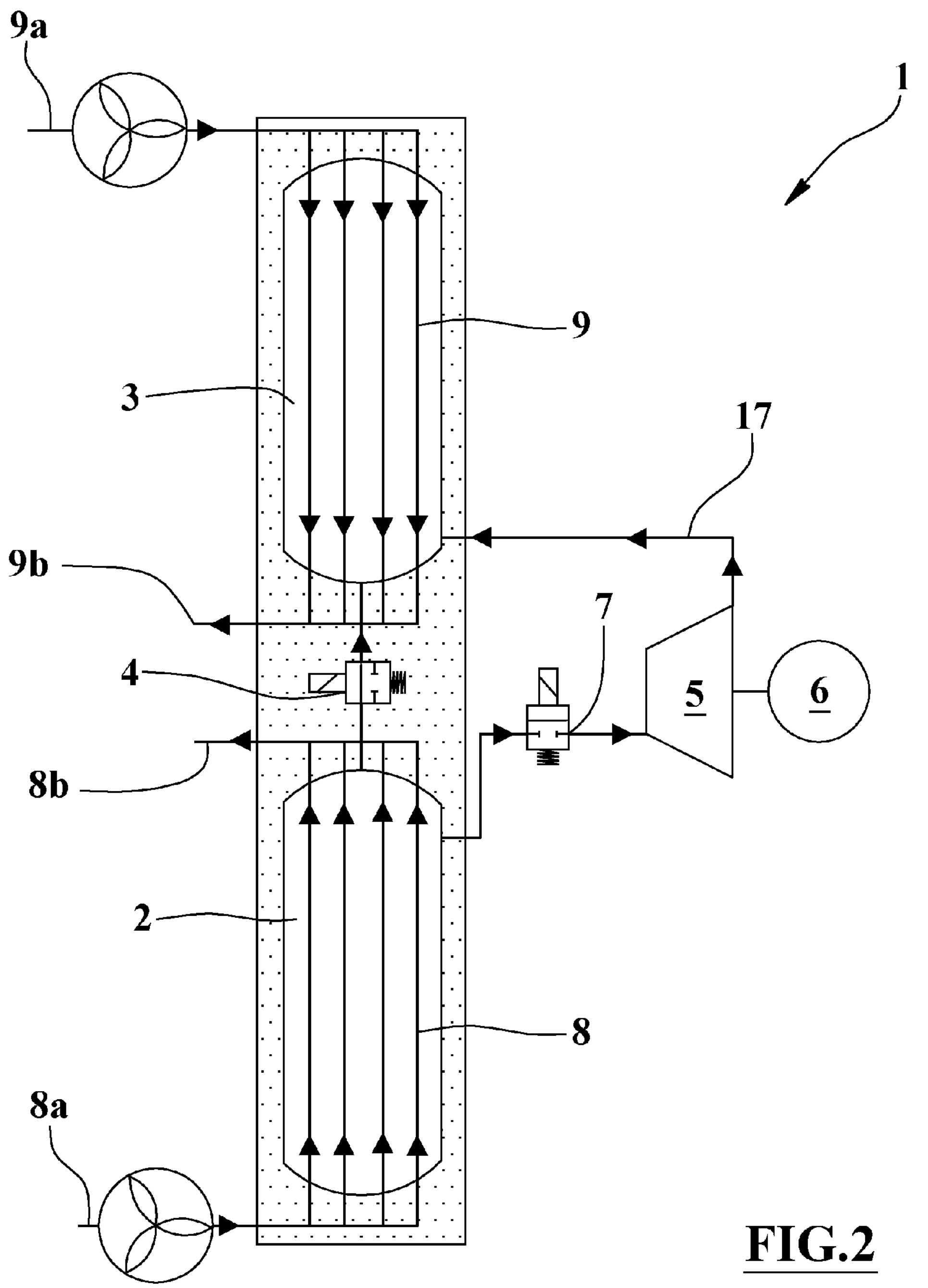

FIG.2

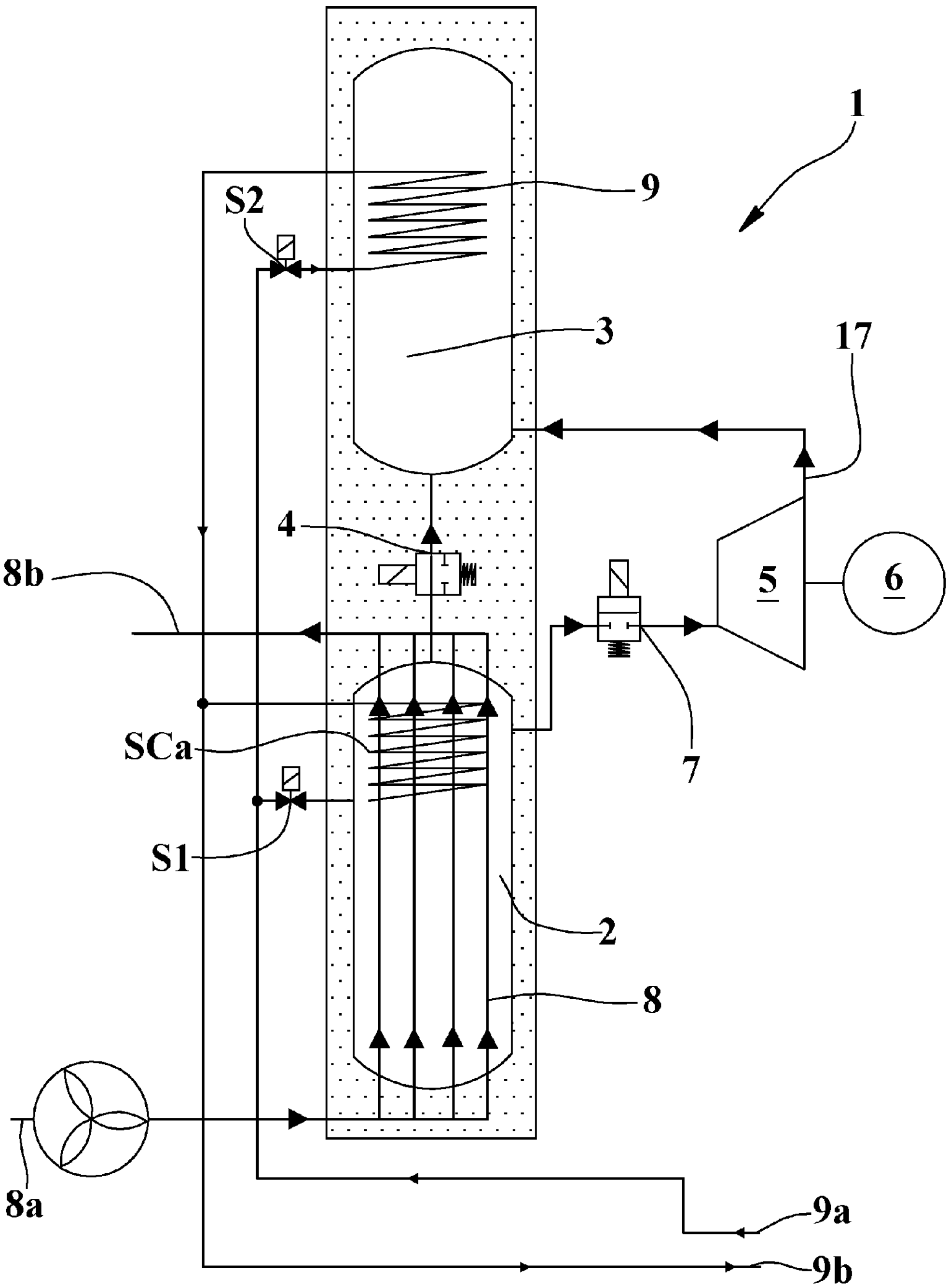

FIG.3

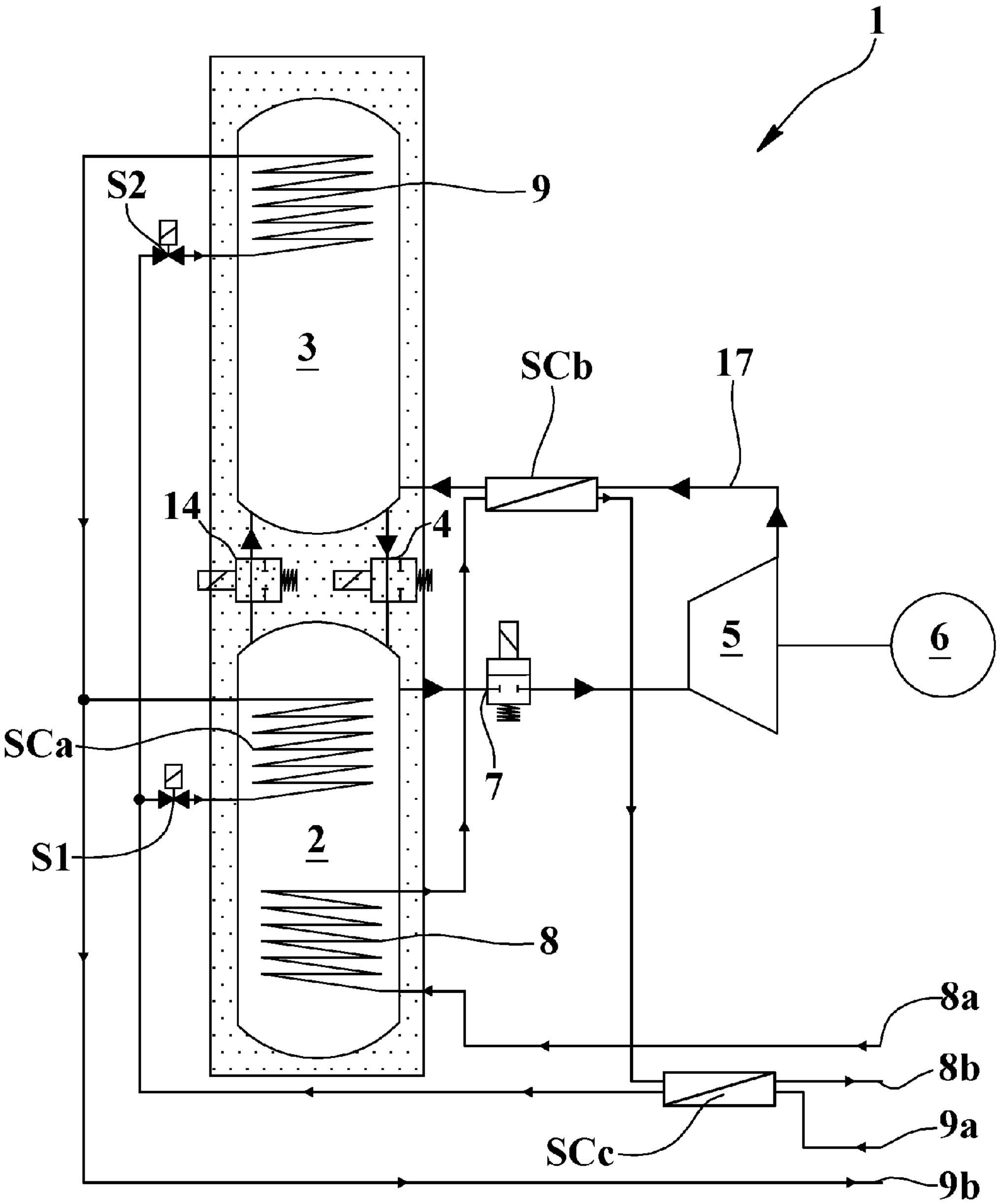

FIG.4

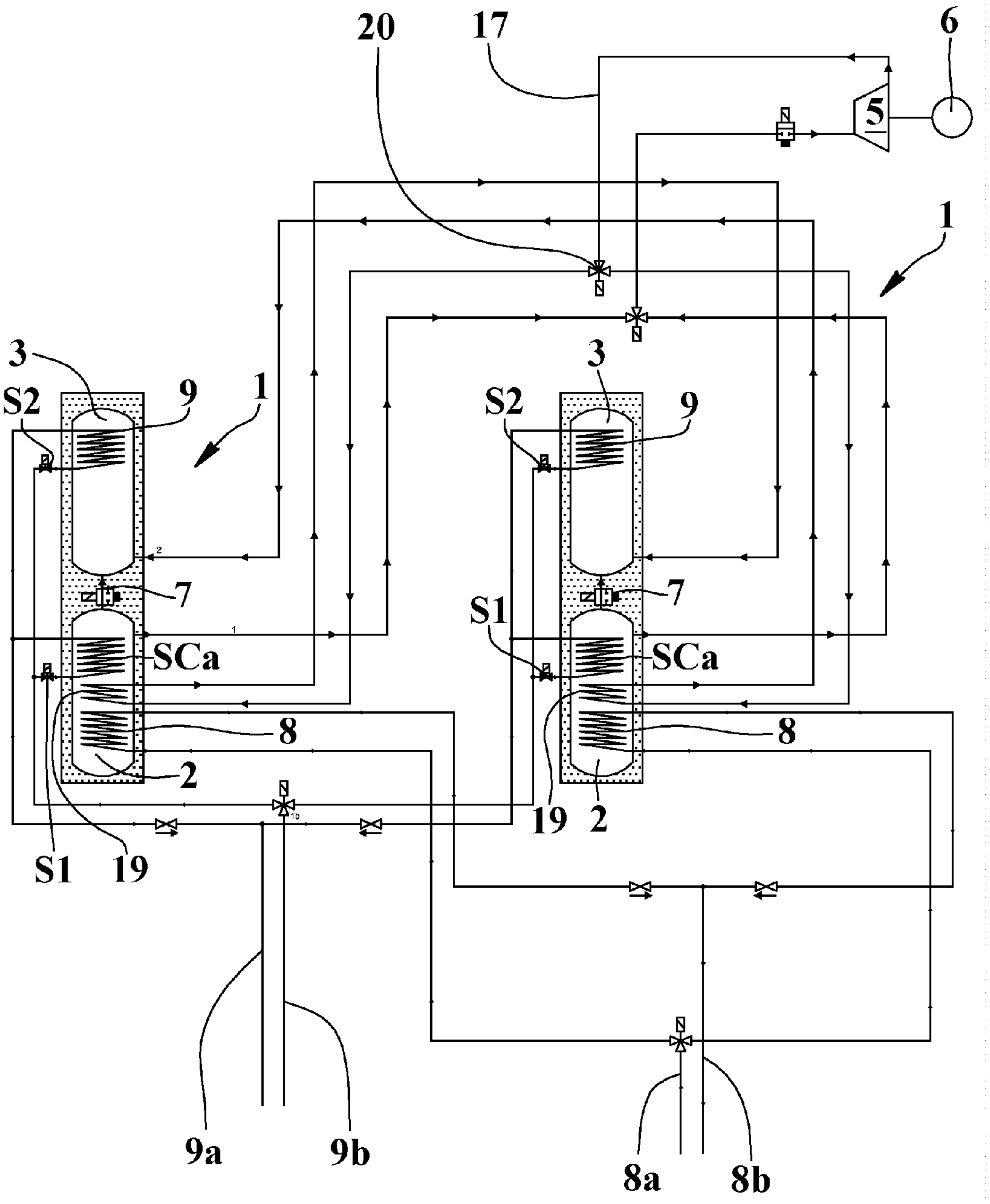

FIG.5

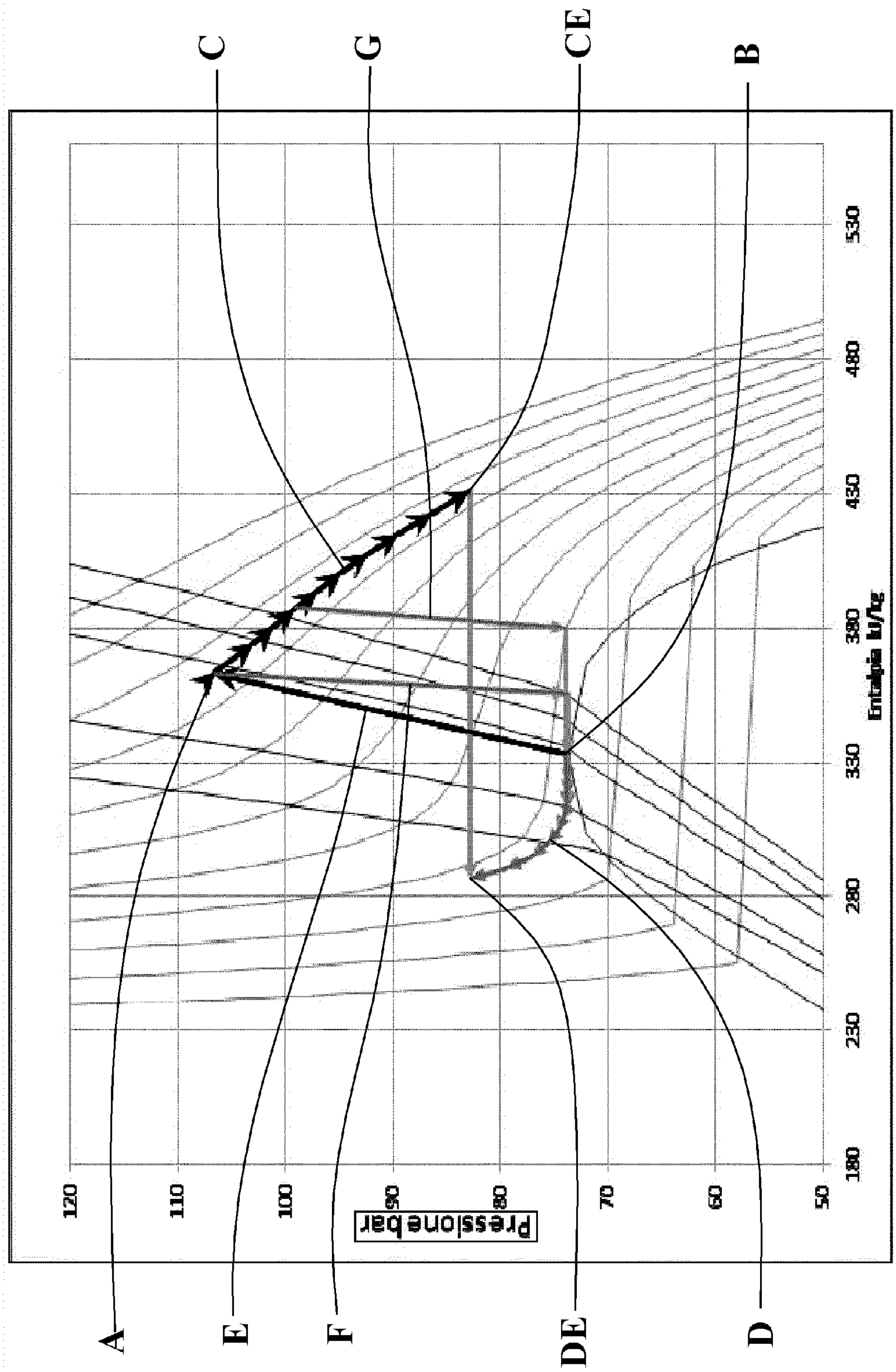
C
G
CE
B
A
E
F
DE
D
Pressione bar
120
110
100
90
80
70
60
50
Entalpia kJ/kg
180
230
280
330
380
430
480
530

FIG.6

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 13 16 6091

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	EP 1 801 364 A1 (DOSHISHA [JP]; MAEKAWA SEISAKUSHO KK [JP]; SHOWA DENKO KK [JP]; SHOWA) 27 June 2007 (2007-06-27) * paragraphs [0031] - [0038]; figure 2 * -----	1-15	INV. F01K25/04 F01K25/10
X	DE 101 26 403 A1 (HOLDER KARL LUDWIG [DE]) 6 December 2001 (2001-12-06) * paragraphs [0001] - [0014], [0021] - [0024], [0031] - [0032], [0037] - [0045]; figure 1 * -----	1-15	
X	DE 10 2009 057179 A1 (WERBA HANS [DE]) 9 June 2011 (2011-06-09) * paragraph [0016]; figure 4b * -----	1-15	
A	DE 36 24 357 A1 (STANGER HARALD [DE]) 28 January 1988 (1988-01-28) * Ref.Nummern (2,3); column 1, lines 64-68; figure 1 * -----	1,15	
X	DE 10 2005 049215 A1 (GUNDERMANN ALF [DE]; MRUKWIA KARL [DE]) 19 April 2007 (2007-04-19) * paragraphs [0005] - [0009], [0038] - [0043]; figure 1 * -----	1-15	TECHNICAL FIELDS SEARCHED (IPC) F01K

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	19 July 2013	Henkes, Roeland

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons
& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 13 16 6091

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

19-07-2013

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 1801364 A1	27-06-2007	CN 101065558 A	31-10-2007
		CN 101556096 A	14-10-2009
		EP 1801364 A1	27-06-2007
		JP 4686464 B2	25-05-2011
		US 2007199323 A1	30-08-2007
		WO 2006030779 A1	23-03-2006
DE 10126403 A1	06-12-2001	NONE	
DE 102009057179 A1	09-06-2011	NONE	
DE 3624357 A1	28-01-1988	NONE	
DE 102005049215 A1	19-04-2007	DE 102005049215 A1	19-04-2007
		EP 1941160 A1	09-07-2008
		WO 2007042215 A1	19-04-2007

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- EP 1801364 A1 **[0003]**
- DE 10126403 A1 **[0004]**
- DE 102009057179 **[0005]**
- DE 3624357 **[0006]**
- DE 102005049215 **[0007]**