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(71) Applicant: **Staicovici, Mihail-Dan**
Bucharest (RO)

(72) Inventor: **Staicovici, Mihail-Dan**
Bucharest (RO)

(54) MOTHER & FATHER HYBRID COMPRESSION FOR WORKING AND HEATING

(57) Plant, connected to a sink / heat source of ambient temperature, producing for industry, agriculture, research, household, etc.,

- in the 1st place, hybrid compression working based on the synergy between components of single-stage absorption heating cycle, Osenbrück cycle and Rankine cycle types, abbreviated by M&FHCHW;
- in the 2nd place, hybrid compression working based on the synergy between components of Osenbrück cycle and Rankine cycle types, abbreviated by FWORK;
- in the 3rd place, hybrid compression heating based on the synergy between components of single-stage absorption heating cycle and Osenbrück cycle, abbreviated by M&FHCH.

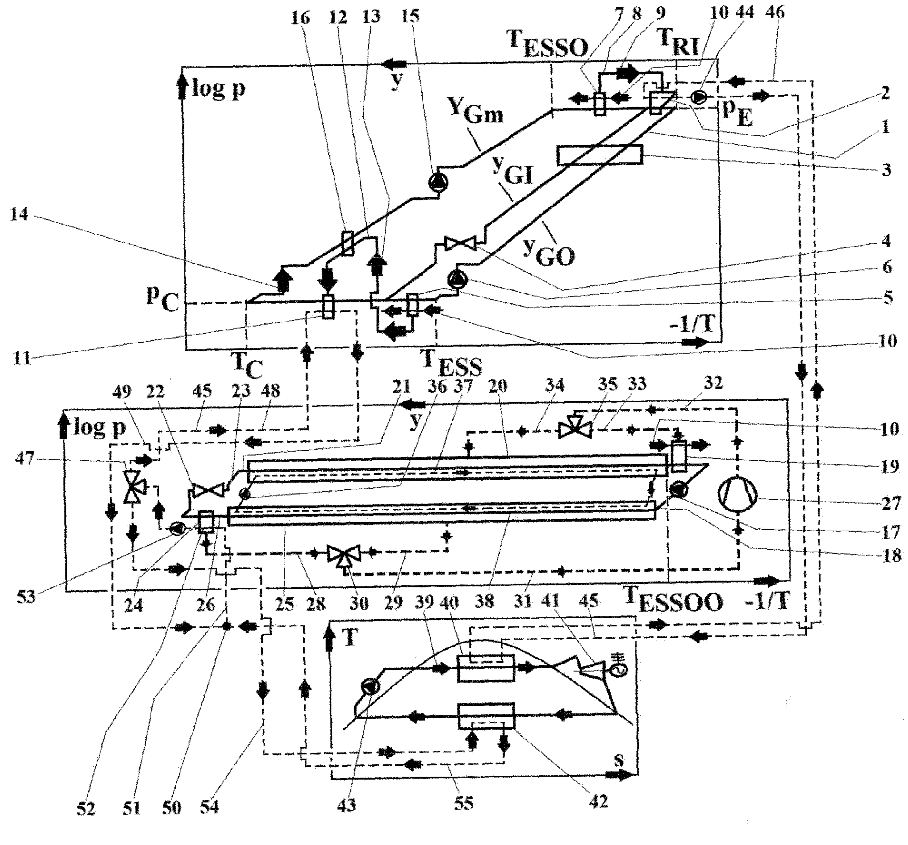


Figure 1.

EP 4 177 540 A1

Description

[0001] The present invention refers to a hybrid compression plant producing working and heating for industry, agriculture, research, household, etc., supplied by ambient temperature sink/heat sources.

[0002] There are known plants proposed by the author to produce working and refrigeration when supplied by ambient temperature sink/heat sources. These, named generically "Mother And Father Hybrid Compression Plant For Refrigeration And Working", make the object of a Sweden PRV-2100124-3 / 2021-08-06 patent file and are abbreviated by M&FHCR and M&FHCW, respectively. On one side, the M&FHCR plant bases on the synergy between an absorption technology section and a mechanical vapor compression technology section, abbreviated by ATS and MVCTS, respectively. On the other side, M&FHCW plant is a synergic joint between the M&FHCR plant and the Rankine Cycle based plant.

[0003] Despite its major advantage, of producing mechanical work or electricity 24 hours/day and each day/year in almost all warm or temperate world climate regions and consuming just the free ambient heat source energy, therefore being the perfect complete nonpolluting power plant, the M&FHCW plant is confronted with a 1st problem, i.e. it cannot be used in cold climate regions with ambient source temperatures much below 0 °C, e.g. T_{ESS} < -5°C, when operated by ammonia-water and ammonia, ones of the best working fluids for this application.

[0004] A 2nd problem of M&FHCW is its structure, which might be considered too complex in certain circumstances.

[0005] And last but not least, the new plant solving the 1st problem of M&FHCW in the way we do here, according to the invention, can be modified further in order to produce useful heating effect when needed, and this is considered a 3rd problem and task which M&FHCW is confronted with.

[0006] The plant, according to the invention 1st objective, solves the 1st M&FHCW problem by using in its structure, on one side, a single-stage heat transformer as ATS, supplied by ambient heat sources, instead of the single-stage refrigeration ATS, and, on the other side, the MVCTS provides the internal sink source of the ATS and Rankine Cycle based plant condensers, in such a way that ATS resorber supplies with heat source the Rankine Cycle based plant generator and this is producing the useful working output. The plant solving the 1st objective, according to the invention, is named "Mother & Father Hybrid Compression For Heat-To-Work", abbreviated by M&FHCHW.

[0007] The plant, according to the invention 2nd objective, solves the 2nd M&FHCW problem by eliminating from its structure the ATS and keeping just the MVCTS and the Rankine Cycle based plant in a synergic coupling, in such a way that the MVCTS plays the role of internal sink source of the Rankine Cycle based plant, and the latter is supplied by heat source of ambient temperature in order to produce the useful working output. The plant solving the 2nd objective, according to the invention, is named "Father Working by Osenbrück and Rankine Kit", abbreviated by FWORK.

[0008] The plant, according to the invention 3rd objective, solves the 3rd problem by keeping out of the M&FHCHW structure just the ATS and MVCTS and eliminating the Rankine Cycle based plant, so that ATS is supplied externally by the heat source of ambient temperature, the MVCTS provides the sink source for the ATS condenser, and ATS resorber is producing the most effective useful effect of heating ever. The plant solving the 3rd objective, according to the invention, is named "Mother & Father Hybrid Compression For Heat", abbreviated by M&FHCH.

[0009] The advantages offered by the invention are the following:

- M&FHCHW and FWORK can be applied 24 hours/day and each day/year, practically in all cold and temperate + warm climate regions of the world, respectively, producing mechanical work or electricity through the use of the ambient source as heat source;
- M&FHCH benefits of the highest COP of heating, out of all heat pumps, has the lowest discharge gas temperature and a compressor with the smallest physical size, for same heat pumping application;
- Using just the ambient sink/heat source for supply, which is free, M&FHCHW, FWORK and M&FHCH plants could have a substantial impact to environment temperature decrease, therefore to planet global warming decrease.

[0010] Next, it is given an example of the invention achievement, in conjuncture with Figures 1 to 7.

- Fig. 1. Schematic of M&FHCHW;
- Fig. 2. Working effectiveness study case of M&FHCHW vs. T_{ESS};
- Fig. 3. Schematic of FWORK;
- Fig. 4. Working efficiency study case of FWORK vs. T_{ESS};
- Fig. 5. Schematic of M&FHCH;
- Fig. 6. Heating effectiveness study case of M&FHCH vs. T_{ESS}.
- Fig. 7. Heating temperature study case correlated with Fig. 6 results in case of M&FHCH, vs. T_{ESS}.

[0011] The plant M&FHCHW is shown as example of achievement in Fig. 1, according to the invention. It is a three-component plant, including 1st a known *single-stage absorption heating* component, called "mother", located in the upper part and represented in the diagram log p- (-1/T), 2nd an *Osenbrück absorption-compression single-stage* component, called "father" and located in the middle, represented as well in the diagram log p- (-1/T), known in the literature as a plant with absorption/compression cycle, or as vapor-compression cycle with mixture circuits (see e.g. Staicovici M.-D., 2014, Coabsorbent and Thermal Recovery Compression Heat Pumping Technologies. Springer Verlag, 2014, see Fig. 3.38 and Fig. 3.39), based on a Clausius-Rankine process producing heat pumping with mechanical work input, and 3rd a known *Rankine Cycle* based component, represented in the T-s diagram and located to the bottom. In the 1st place, the *single-stage absorption heating* component structure and operation are described next,

- a closed loop mixture circuit 1, of adequate refrigerant-absorbent mixture, connects serially the devices, high-pressure resorber 2, rich-weak concentration mixture primary-secondary recovery heat exchanger 3, expansion valve 4, low-pressure generator 5, mixture pump 6, heat exchanger 3, high-pressure resorber 2; in Fig. 1 we noted the rich and weak concentrations, exiting the high-pressure resorber 2 and low-pressure generator 5, by y_{GI} and y_{GO}, respectively, and the low- and high-pressures by p_C and p_E, respectively; also, the inlet and outlet temperatures of high-pressure resorber 2 and low-pressure generator 5 are noted by $T_{RI}(p_E;\ y_{GO})$ and $T_{GO}(p_C;y_{GO}) = T_{ESS}$, respectively;
- a high-pressure evaporator 7 is connected on vapor-side with the high-pressure resorber 2 through pipe 8 and evaporates the refrigerant 9 of mean concentration Y_{Gm}, in order to be resorbed by the high-pressure resorber 2 and to produce the resorption heating effect; the evaporator 7 and low-pressure generator 5 heat sources are the ambient heat source 10;
- a low-pressure M-condenser 11 is connected on vapor-side with the low-pressure generator 5 through pipe 12 and condenses at temperature $T_C(p_C;\ Y_{Gm})$, with $T_C < T_{ESS} \leq T_{ESSO}$, the vapor 13 of concentration Y_{Gm}, coming of the low-pressure generator 5, in order to obtain the refrigerant condensate 14, which subsequently is pumped by pump 15, is preheated in the preheater 16 by sub-cooling the refrigerant vapor 13 and further is evaporated in the high-pressure evaporator 7;
- during a season, or even a full day, the temperature of the ambient sink/heat supplying source, noted generically by T_a, may vary and covers a certain interval of values, T_a E [T_{ESS}, T_{ESSO}], $T_{ESS} \leq T_{ESSO}$; in order that the *single-stage absorption heating* component operates continuously, the y_{GI} and y_{GO} concentration lines, named also isosteres and given in Fig. 1 as well, of the closed loop mixture circuit 1, must be kept constant when T_a covers the interval [T_{ESS}, T_{ESSO}]; bearing this remark in mind, an appropriate cycle design must keep the low-pressure generator 5 position constant in the refrigerant-absorbent working combination solubility field, i.e. $T_{GO}(p_C;\ y_{GO}) = T_{ESS} = const.$, and to ensure the evaporator 7 heat supply with the gliding temperature $T_E(p_E;\ Y_{Gm}) = T_{ESSO}$ when $T_a = T_{ESSO} > T_{ESS}$; in a real cycle operation, the higher the T_{ESS} temperature, the higher the effectiveness of the *single-stage absorption heating* component, obviously; however, when designing the closed loop mixture circuit 1, the $T_{GO}(p_C;y_{GO}) = T_{ESS}$ design temperature must be chosen below the minimum value of T_a which could be recorded during the entire period considered of operation of the *single-stage absorption heating* component, for obvious reasons; also, in the presentation above we avoided to introduce the small temperature differences necessary in a real heat exchange between source and devices, in order to simplify the presentation;
- and last but not least, the useful heat produced in the high-pressure resorber 2 and the condensing heat of the low-pressure M-condenser 11 are rejected by special closed loops which will be presented later in this section describing M&FHCHW plant of Fig. 1.

[0012] In the 2nd place, the *Osenbrück absorption-compression single-stage* component structure and operation are described next,

- a closed loop adequate refrigerant-absorbent mixture circuit, made up of serially connected devices, i.e. a mixture pump 17, mounted on a pipe 18, a high-pressure resorber 19, provided with a short operation temperature interval in the low-to-moderate concentration domain of the mixture solubility field, a high-pressure gax resorber 20, provided with a large operation temperature interval in the moderate-to-high concentration domain of the mixture solubility field, both serially connected on the pipe 21, an expansion valve 22, mounted on a pipe 23, a low-pressure desorber 24, provided with a short operation temperature interval in the high concentration domain of the mixture solubility field and a low-pressure gax desorber 25, provided with a large operation temperature interval in the moderate-to-low concentration domain of the mixture solubility field, both serially connected on the pipe 26, in such a way that the low-pressure gax desorber 25 and the high-pressure gax resorber 20 have a complete mutual overlapping temperature in operation,
- a compressor 27, externally supplied by mechanical work of compression, which is sucking the refrigerant vapor desorbed by the desorber 24 and gax desorber 25 by means of the pipe 28, pipe 29, connected in parallel and the 3-way valve of control 30, pipe 31, on which the compressor 27 is mounted, and the discharge gas pipe 32, which distributes the compressed refrigerant to the resorber 19 and gax resorber 20, by means of pipe 33 and pipe 34, connected in parallel, and the 3-way valve of control 35,

- means to transfer the rejected heat of the gax resorber 20 to the gax desorber 25, which receives it with the help of a 1st closed loop, circulating a 1st intermediary heat transfer fluid with low freezing point, abbreviated by IHTF-1, and being made up by serially connected devices, i.e. a mixture pump 36 circulating the ITHF-1 in the said closed loop, a secondary pipe 37 of the gax resorber 20, a primary pipe 38 of the gax desorber 25 and the mixture pump 36, and
- a sink source 10 rejecting the heat released by the high-pressure resorber 19;
- some more comments concerning the temperature distribution along the *Osenbrück absorption-compression single-stage* component will be made, instead of being shown in the Fig. 1 diagram, for the sake of a clearer graphical presentation; indeed, the temperature T_{ESSOO}, marked in Fig. 1, is the end-temperature of the high-pressure resorber 19 heat rejection process, performed with the help of the sink source 10; at the same time, T_{ESSOO} is the starting temperature of the process beginning in the gax resorber 20; for a reason easy to understand, the temperature T_{ESSOO} is a temperature of design, chosen in such a way that inequalities $T_{ESSOO} > T_{ESSO} \geq T_{ESS}$ fulfil always while T_a covers the [T_{ESS}, T_{ESSO}] excursion during a period of time considered in M&FHCHW operation, i.e. $T_a \in [T_{ESS}, T_{ESSO}]$, as mentioned prior; the temperature T_{ESSOO} is higher by a minimum temperature pinch, e.g. δT = (1.5 - 2)°C, as compared to the outlet temperature of the low-pressure gax desorber 25, i.e. $T_{Dgax,o} = T_{ESSOO} - \delta T$; continuing, the inlet temperature of low-pressure gax desorber 25 is lower as compared to low-pressure M-condenser 11 condensing temperature $T_C(p_C;\ Y_{Gm})$ by a minimum temperature pinch δT, i.e. $T_{Dgax,I} = T_C - \delta T$, and as well as compared to the high-pressure gax resorber 20 outlet temperature, i.e. $T_{Dgax,I} = T_{Rgax,O} - \delta T$;

[0013] In the 3rd place, the *Rankine Cycle* based component structure and operation are described next,

- it is operated by an adequate working fluid with low freezing temperature 39, which covers known devices serially connected, i.e. a high-pressure generator 40, a turbo-generator 41, a low-pressure condenser 42 and a pump 43 circulating the working fluid condensate 39;
- the high-pressure generator 40 is supplied by the resorption heat as heat source coming of the high-pressure resorber 2, rejected and enabled to be accessed by means of a 2nd closed loop covered by a 2nd intermediary heat transfer fluid with low freezing point, abbreviated IHTF-2, made up of serially connected devices, i.e. a pump 44 circulating ITHF-2 in the said closed loop, a primary pipe 45 of the high-pressure generator 40, a secondary pipe 46 of the high-pressure resorber 2 and the pump 44;

[0014] In the 4th place, the M&FHCHW condensing processes are enabled by a synergic link between the low-pressure M-condenser 11 and the low-pressure desorber 24, on one side, and between the low-pressure condenser 42 and the low-pressure desorber 24, on the other side; the coldness is distributed to the M-condenser 11 and condenser 42 with the help of two closed loops, each covered by a 3rd intermediary heat transfer fluid with low freezing point, abbreviated IHTF-3;

- the low-pressure M-condenser 11 and the low-pressure desorber 24 are synergic linked by the closed loop which connects serially the 3-way valve 47, secondary 48 of the low-pressure M-condenser 11, return pipe 49, joint 50 and the pipe 51, connecting serially the secondary 52 of the low-pressure desorber 24, pump 53, circulating IHTF-3 in the two said closed loops and the 3-way valve 47;
- the low-pressure condenser 42 and the low-pressure desorber 24 are synergic linked by the closed loop which connects serially the 3-way valve 47, secondary 54 of the low-pressure condenser 42, return pipe 55, joint 50 and the pipe 51, connecting serially said devices;

[0015] In Fig. 2, a study case results of the net specific work, W_{ns}, [$kJ * kg^{-1}$], are shown, vs. T_{ESS}, according to the invention. A model of M&FHCHW has been elaborated for steady-state operation, in this respect. The results are obtained considering that the *single-stage absorption heating* and *Osenbrück absorption-compression single-stage* components are operated by NH_3-H_2O and the *Rankine Cycle* based component is operated by NH_3. The net specific work is positive in the thermodynamic meaning, calculated by the difference between the work output produced by the turbo-generator 41 and the work input consumed by the compressor 27 and mixture pumps. Fig. 2 results is plotting a family of curves, having T_{ESSO} temperature as parameter, T_{ESSO} = 0, -9, -18, -27, -36 *and* - 40.5 °C and T_{ESSOO} = 21°C. The exergy efficiency of the *Rankine Cycle* based component is $\eta_{ex.}$ = 0.75. The results confirm theoretically that unlike M&FHCW, the M&FHCHW plant is capable to produce mechanical work up to external sink source temperatures of $T_{ESS} \geq$ -40.5°C.

[0016] The plant FWORK is shown as example of achievement in Fig. 3, according to the invention. It is a two-component plant, including the *Osenbrück absorption-compression single-stage* component, synergic coupled with the *Rankine Cycle* based component. Both components are the same as those described in Fig. 1 and for this reason, the identical devices of the structure are referred to by the same figures. The only differences are in two cases: i) the way the high-pressure generator 40 is supplied with heat source, and ii) the synergic link between the low-pressure condenser

42 and the low-pressure desorber 24;

- in case (i), the high-pressure generator 40 is supplied by the ambient heat source 10 with the help of a closed loop covered by a 4th intermediary heat transfer fluid with low freezing point, abbreviated IHTF-4, serially connecting the pipe 56, pump 57, circulating IHTF-4 in the said closed loop, primary 58 of the high-pressure generator 40, secondary pipe 59 of the ambient heat source 10 and pipe 56;
- in case (ii), the coldness produced by the low-pressure desorber 24 is distributed to the low-pressure condenser 42 with the help of a closed loop covered by a 5th intermediary heat transfer fluid with low freezing point, abbreviated IHTF-5, serially connecting the primary 60 of the low-pressure condenser 42, return pipe 61, secondary 62 of the low-pressure desorber 24, pump 63, circulating IHTF-5 in the said closed loop and secondary pipe 60;

[0017] In Fig. 4, a study case results of the net specific work, W_{ns}, $[kJ * kg^{-1}]$, are shown, vs. T_{ESS}, according to the invention. A model of FWORK has been elaborated for steady-state operation in this respect, too. The results are obtained considering that the *Osenbrück absorption-compression single-stage* component is operated by NH_3 - H_2O and the *Rankine Cycle* based component is operated by NH_3. The net specific work is positive in the thermodynamic meaning again, calculated by the difference between the work output produced by the turbo-generator 41 and the work input consumed by the compressor 27 to compress a mass unit of NH_3 and by mixture pumps. Also, the plot is for T_{ESSOO} = 66°C. The exergy efficiency of the *Rankine Cycle* based component is $\eta_{ex.}$ = 0.75. The results confirm theoretically that unlike M&FHCW, the FWORK plant is capable to produce mechanical work with similar efficiency up to external sink source temperatures of $T_{ESS} \geq$ -8°C and with a much simpler structure. The net specific work, W_{ns} capacity can be increased, multiplying the mass flow rate of the working fluid in the *Osenbrück* component to the higher values comparable to those used in M&FHCW or M&FHCHW. And last but not least, similar to results obtained for W_{ns} in case of M&FHCW, in case of FWORK, W_{ns} is a linear function of T_{ESS} as well, i.e. $\frac{dW(T_{ESS})}{dT_{ESS}} \cong 0.9158 = const. [kJ * (kg * K)^{-1}]$. The results of Fig. 4 do not include the consumption work for sources supply.

[0018] The plant M&FHCH is shown as example of achievement in Fig. 5, according to the invention. It is a two-component plant, including the *single-stage absorption heating* component synergic coupled with the *Osenbrück absorption-compression single-stage* component. Both components are the same as those described in Fig. 1 and for this reason, the identical devices of the structure are referred to by the same figures. The only differences are in two cases: i) the way the high-pressure resorber 2 is used as heat source, and ii) the synergic link between the low-pressure M-condenser 11 and the low-pressure desorber 24;

- in case (i), the high-pressure resorber 2 is heat source for an external usefully heated source 66 with the help of a closed loop covered by a 6th intermediary heat transfer fluid provided optionally with low freezing point, abbreviated IHTF-6, serially connecting the secondary 64 of the high-pressure resorber 2, pump 65, circulating IHTF-6 in the said closed loop, the primary 67 of the heated source 66 heat exchanger and the secondary 64 of the high-pressure resorber 2;
- in case (ii), the coldness produced by the low-pressure desorber 24 is distributed to the low-pressure M-condenser 11 with the help of a closed loop covered by a 7th intermediary heat transfer fluid with low freezing point, abbreviated IHTF-7 serially connecting the secondary 68 of the low-pressure desorber 24, pump 69 circulating IHTF-7 in the said closed loop, primary 70 of the low-pressure M-condenser 11, return pipe 71 and the secondary 68 of the low-pressure desorber 24.

[0019] Figures 6 and 7, correlated one to the other, present, according to the invention, a study case results of M&FHCH heating effectiveness, $COP_{M\&FHCH}$, $[kJ_{heat}/kJ_{work}]$, and of the temperature inlet, T_{RI}, [°C], of the high-pressure resorber 2 delivering the useful heat, plotted vs. T_{ESS}, respectively. The results are obtained considering that the *single-stage absorption heating* and *Osenbrück absorption-compression single-stage* components are operated by NH_3 - H_2O. $COP_{M\&FHCH}$ is defined in an usual way, as the useful heat delivered divided by the compressor 27 work input. The plot is done having T_{ESSO} temperature as parameter, T_{ESSO} = 0, -9, -18, -27, -36 and-40.5 °C and T_{ESSOO} = 21°C, similar to Fig. 2. The results show high $COP_{M\&FHCH}$ values achieved with low T_{ESS} sink temperatures and usual T_{RI} household heating and warm water preparation temperatures. Indeed, supposing a heating temperature $T_{RI} \approx$ 60°C would be required, from Fig. 7 it results that, according to isothermal $T_{ESSO} \approx$ -18°C, the sink must be T_{ESS} > -10°C, wherefrom, from Fig. 6 it results $COP_{M\&FHCH} \approx$ 9.5, which is a quite remarkable high effectiveness in this case.

Claims

1. Plant applicable to working achievement for industry, agriculture, research, household, etc., supplied by ambient temperature sink/heat sources, including

    - first, a closed loop of adequate refrigerant-absorbent mixture connecting serially a high-pressure resorber, a rich-weak concentration mixture heat exchanger, an expansion valve, a low-pressure generator, a mixture pump, on one side, and a high-pressure evaporator, a low-pressure M-condenser and a preheater, on the other side,
    - second, a closed loop of adequate refrigerant-absorbent mixture connecting serially a mixture pump, a high-pressure resorber, a high-pressure gax resorber, an expansion valve, a low-pressure desorber, a low-pressure gax desorber, a closed loop for gax heat transfer, on one side, and a compressor and 3-way valves of control, on the other side,
    - third, a closed loop of adequate working fluid connecting serially a high-pressure generator, a turbo-generator, a low-pressure condenser and a pump and
    - fourth, closed circuits for synergic link between internal heat rejecting and heat receiving devices,

    characterized in that

    - it is using in a first place a single-stage absorption heating cycle based component including a closed loop mixture circuit 1 of adequate refrigerant-absorbent mixture connecting serially the next devices, a high-pressure resorber 2, a rich-weak concentration mixture recovery heat exchanger 3, an expansion valve 4, a low-pressure generator 5 and a mixture pump 6, then
    - its high-pressure evaporator 7 is connected on vapor-side with the high-pressure resorber 2 through pipe 8 and evaporates the refrigerant 9 in order to be resorbed by the high-pressure resorber 2 and to produce the resorption heating effect when the evaporator 7 and low-pressure generator 5 are supplied by the ambient heat source 10, and
    - its low-pressure M-condenser 11 is connected on vapor-side with the low-pressure generator 5 through pipe 12 and condenses the vapor 13 coming of the low-pressure generator 5 in order to obtain the refrigerant condensate 14 which subsequently is pumped by pump 15, is preheated in the preheater 16 by sub-cooling the refrigerant vapor 13 and further is evaporated in the high-pressure evaporator 7, for

    being linked synergic in a second place to an Osenbrück cycle based component, including

    - a closed loop adequate refrigerant-absorbent mixture connecting serially the next devices, a mixture pump 17, mounted on a pipe 18, a high-pressure resorber 19, provided with a short operation temperature interval in the low-to-moderate concentration domain of the mixture solubility field, a high-pressure gax resorber 20, provided with a large operation temperature interval in the moderate-to-high concentration domain of the mixture solubility field, both serially connected on the pipe 21, an expansion valve 22, mounted on a pipe 23, a low-pressure desorber 24, provided with a short operation temperature interval in the high concentration domain of the mixture solubility field and a low-pressure gax desorber 25, provided with a large operation temperature interval in the moderate-to-low concentration domain of the mixture solubility field, both serially connected on the pipe 26, in such a way that the low-pressure gax desorber 25 and the high-pressure gax resorber 20 have a complete mutual overlapping temperature in operation, and further
    - its compressor 27 is externally supplied by mechanical work of compression and is sucking the refrigerant vapor desorbed by the desorber 24 and gax desorber 25 by means of the pipe 28, pipe 29, connected in parallel and the 3-way valve of control 30, pipe 31, on which the compressor 27 is mounted, and the discharge gas pipe 32, which distributes the compressed refrigerant to the resorber 19 and gax resorber 20, by means of pipe 33 and pipe 34, connected in parallel, and the 3-way valve of control 35, and benefits of
    - means to transfer the rejected heat of the gax resorber 20 to the gax desorber 25, which receives it with the help of a 1st closed loop, circulating a 1st intermediary heat transfer fluid with low freezing point, abbreviated by IHTF-1, and being made up by serially connected devices, i.e. a mixture pump 36 circulating the ITHF-1 in the said closed loop, a secondary pipe 37 of the gax resorber 20, a primary pipe 38 of the gax desorber 25 and the mixture pump 36, and
    - a sink source 10 rejecting the heat released by the high-pressure resorber 19, in order to

    be linked synergic in a third place to a Rankine cycle based component, including

- a closed loop operated by an adequate working fluid 39 which covers next devices serially connected, a high-pressure generator 40, a turbo-generator 41, a low-pressure condenser 42 and a pump 43 circulating the working fluid condensate, and
- the high-pressure generator 40 is supplied by the resorption heat source coming of the high-pressure resorber 2 and enabled to be accessed by means of a 2^{nd} closed loop covered by a 2^{nd} intermediary heat transfer fluid with low freezing point, abbreviated IHTF-2, made up of serially connected devices, i.e. a pump 44 circulating ITHF-2 in the said closed loop, a primary pipe 45 of the high-pressure generator 40, a secondary pipe 46 of the high-pressure resorber 2 and the pump 44, so that

the whole plant condensing processes are enabled in the fourth place,

- on one side, by a synergic link between the low-pressure M-condenser 11 and the low-pressure desorber 24 with the help of a closed loop covered by a 3^{rd} intermediary heat transfer fluid with low freezing point, abbreviated IHTF-3, which connects serially the 3-way valve 47, secondary 48 of the low-pressure M-condenser 11, return pipe 49, joint 50 and the pipe 51, connecting serially the secondary 52 of the low-pressure desorber 24, pump 53, circulating IHTF-3 in the said closed loop, and
- on the other side, by a synergic link between the low-pressure condenser 42 and the low-pressure desorber 24 with the help of a closed loop covered by IHTF-3 which connects serially the 3-way valve 47, secondary 54 of the low-pressure condenser 42, return pipe 55, joint 50 and the pipe 51, connecting serially said devices,

in order that the plant yields positive working.

2. Plant applicable to working achievement for industry, agriculture, research, household, etc., supplied by ambient temperature sink/heat sources,, according to claim 1, including the Osenbrück cycle based component synergic coupled with the Rankine cycle based component, **characterized in that,**

   - the high-pressure generator 40 is supplied by the ambient heat source 10 with the help of a closed loop covered by a 4^{th} intermediary heat transfer fluid with low freezing point, abbreviated IHTF-4, serially connecting the pipe 56, pump 57, circulating IHTF-4 in the said closed loop, primary 58 of the high-pressure generator 40, secondary pipe 59 of the ambient heat source 10, on one side,
   - and the coldness produced by the low-pressure desorber 24 is distributed to the low-pressure condenser 42 with the help of a closed loop covered by a 5^{th} intermediary heat transfer fluid with low freezing point, abbreviated IHTF-5, serially connecting the primary 60 of the low-pressure condenser 42, return pipe 61, secondary 62 of the low-pressure desorber 24 and pump 63, circulating IHTF-5 in the said closed loop, on the other side,

   in order that the plant yields positive working.

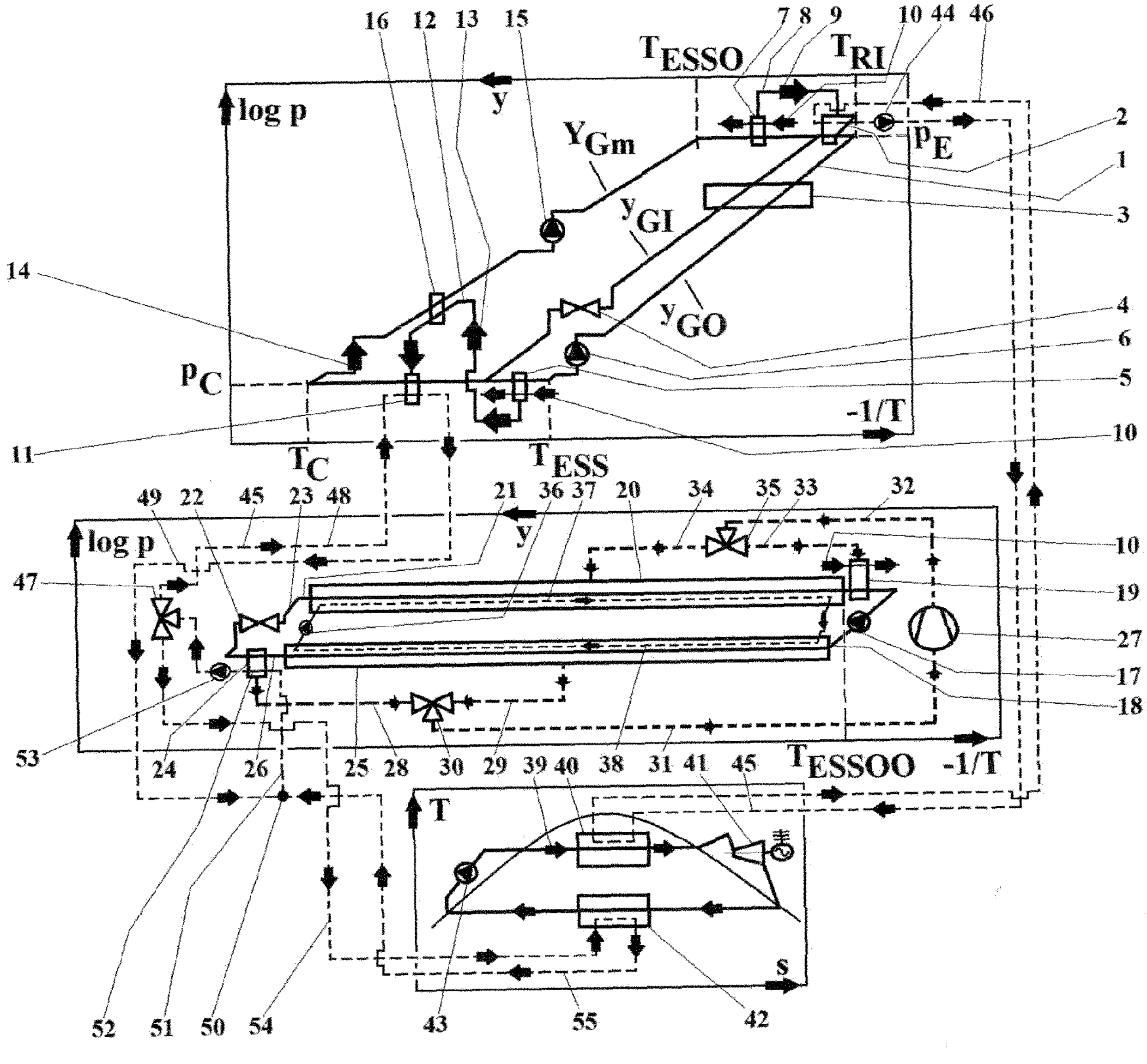
3. Plant applicable to heating achievement for industry, agriculture, research, household, etc., supplied by ambient temperature sink/heat sources,, according to claim 1, including the single-stage absorption heating cycle based component synergic coupled with the Osenbrück cycle based component,
   characterized in that,

   - the high-pressure resorber 2 is heat source for an external usefully heated source 66 with the help of a closed loop covered by a 6^{th} intermediary heat transfer fluid provided optionally with low freezing point, abbreviated IHTF-6, serially connecting the secondary 64 of the high-pressure resorber 2, pump 65, circulating IHTF-6 in the said closed loop, the primary 67 of the heated source 66 heat exchanger and the secondary 64 of the high-pressure resorber 2, on one side,
   - and the coldness produced by the low-pressure desorber 24 is distributed to the low-pressure M-condenser 11 with the help of a closed loop covered by a 7^{th} intermediary heat transfer fluid with low freezing point, abbreviated IHTF-7 serially connecting the secondary 68 of the low-pressure desorber 24, pump 69 circulating IHTF-7 in the said closed loop, primary 70 of the low-pressure M-condenser 11 and return pipe 71, on the other side.

4. Plant, according to claim 1, **characterized in that** the primary or secondary heat exchange is direct.

5. Plant, according to claim 1, **characterized in that** the heat source (59) is free and is **characterized by** a higher temperature obtained for instance by solar heating.

6. Plant, according to claim 1, **characterized in that,** besides liquids with high thermal capacity and density, like e.g. water, lake water, river water or sea water, ambient air is used as well as sink / heat source (10) together with air / liquid cooling / heating towers.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49 22 45 23 48 21 36 37 20 34 35 33 32
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s
52 51 50 54 43 55 42

Figure 1.

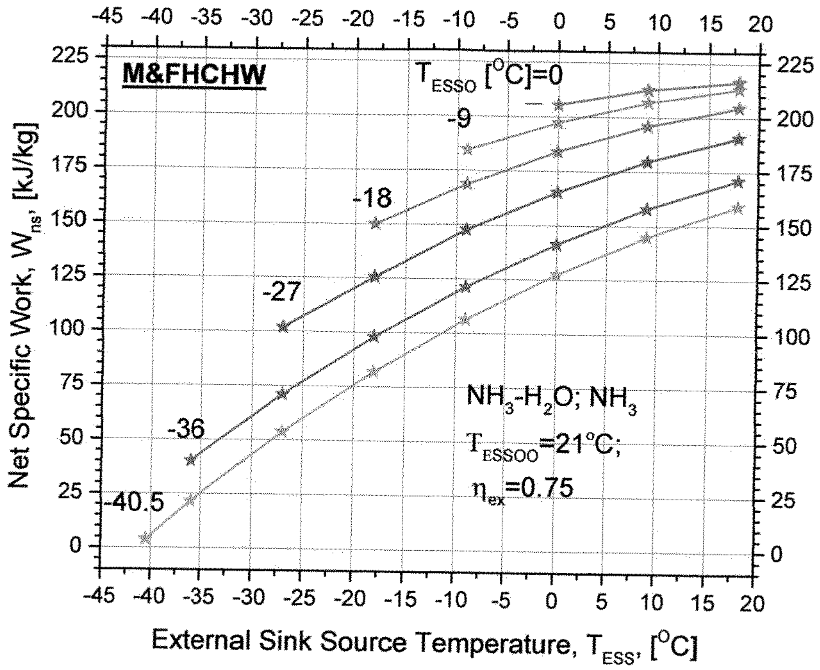

Figure 2.

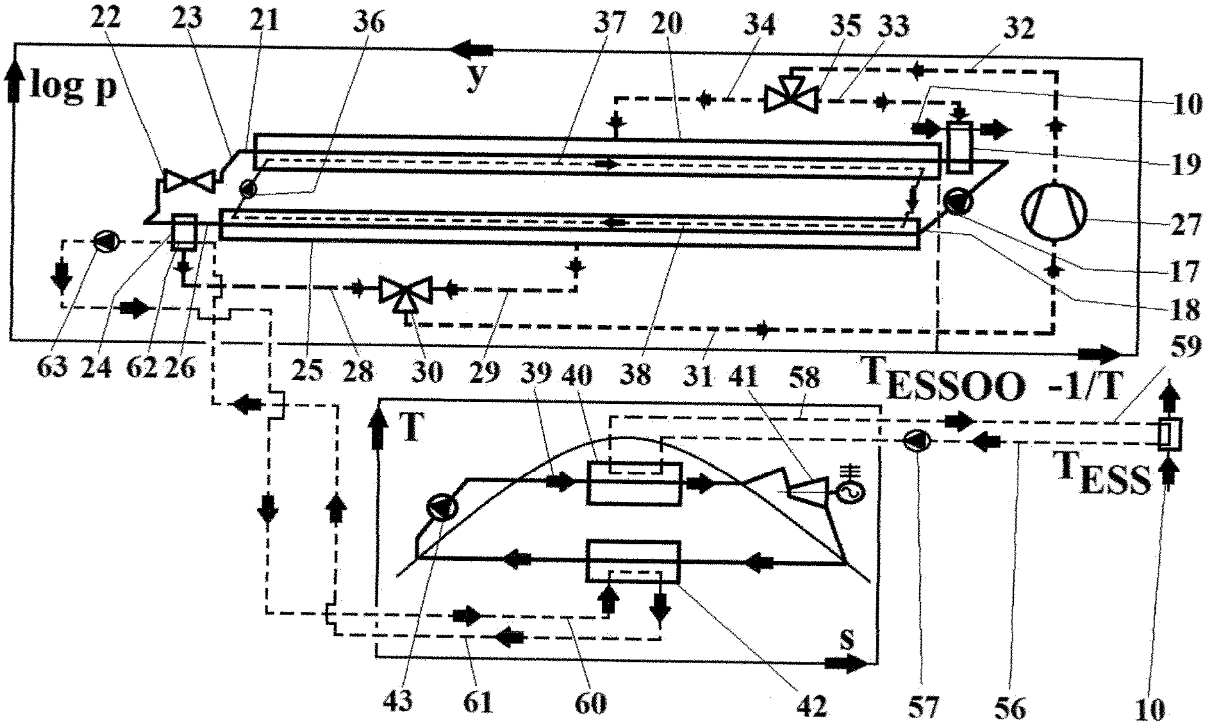

Figure 3.

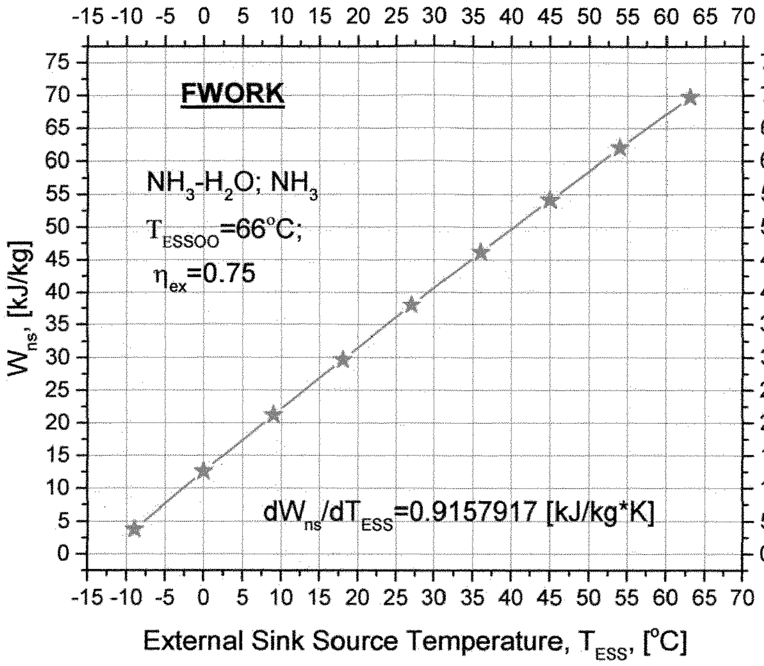

Figure 4.

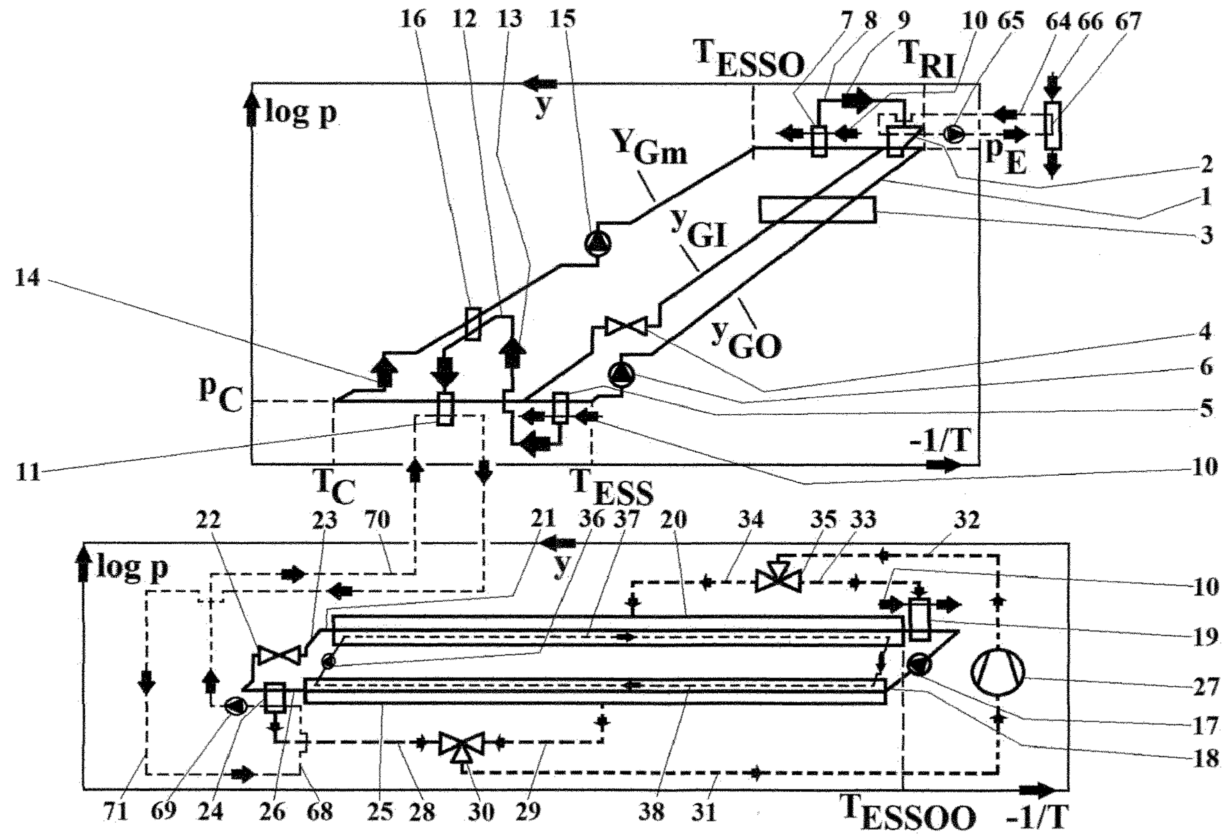

Figure 5.

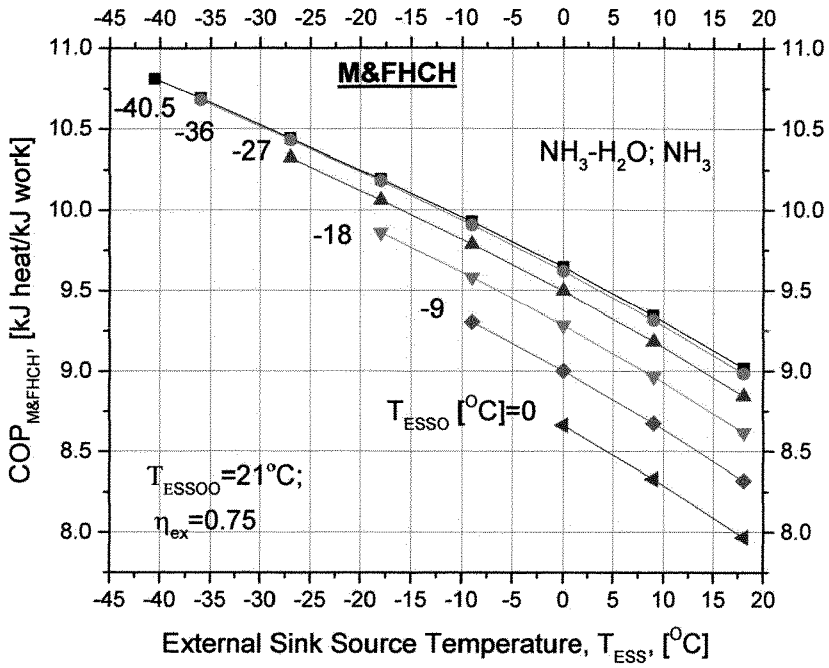

Figure 6.

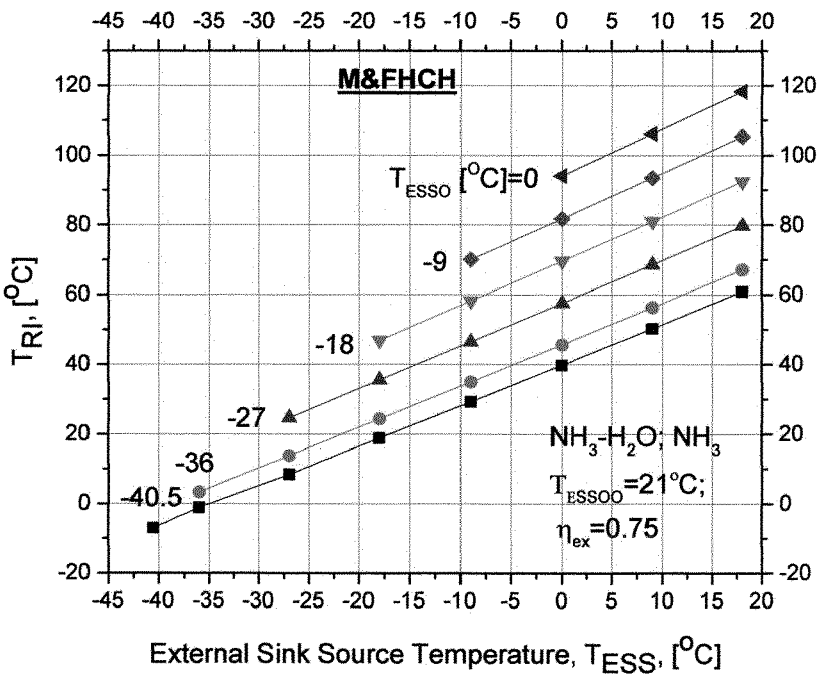

Figure 7.

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EUROPEAN SEARCH REPORT

Application Number
EP 21 00 0324

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	Staicovici Mihail-Dan: "Heat and Mass Transfer Coabsorbent and Thermal Recovery Compression Heat Pumping Technologies" In: "Heat and Mass Transfer Coabsorbent and Thermal Recovery Compression Heat Pumping Technologies", 18 April 2014 (2014-04-18), XP055913988, page 143, * figure 3.39 * -----	1,4,6	INV. F25B15/00 F25B15/02 F25B25/02
A	EP 3 051 233 B1 (STAICOVICI MIHAIL DAN [RO]) 26 August 2020 (2020-08-26) * paragraphs [0012] - [0014]; figure 1 * -----	1,4,6	
			TECHNICAL FIELDS SEARCHED (IPC)
			F25B

~~The present search report has been drawn up for all claims~~

1

Place of search	Date of completion of the search	Examiner
Munich	20 April 2022	Weisser, Meinrad

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)

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Application Number
EP 21 00 0324

CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing claims for which payment was due.

- [ ] Only part of the claims have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due and for those claims for which claims fees have been paid, namely claim(s):

- [ ] No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due.

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

see sheet B

- [ ] All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.

- [ ] As all searchable claims could be searched without effort justifying an additional fee, the Search Division did not invite payment of any additional fee.

- [ ] Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:

- [X] None of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:

  1, 4, 6

- [ ] The present supplementary European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims (Rule 164 (1) EPC).

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LACK OF UNITY OF INVENTION SHEET B

Application Number
EP 21 00 0324

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

1. claims: 1, 4, 6

Plant comprising a single-stage absorption heating cycle, an Osenbrück cycle and a Rankine cycle wherein the generator of the Rankine cycle is connected to the resorber of the absorption heating cycle.

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2. claims: 2, 5

Plant comprising an Osenbrück cycle and a Ranking cycle wherein the high pressure generator is supplied with ambient air.

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3. claim: 3

Plant comprising a single-stage absorption heating cycle and an Osenbrück cycle wherein the resorber of the absorption heating cycle is connected to a heat sink.

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO.

EP 21 00 0324

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.

20-04-2022

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 3051233 B1	26-08-2020	NONE	

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

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Non-patent literature cited in the description

- **STAICOVICI M.-D.** Coabsorbent and Thermal Recovery Compression Heat Pumping Technologies. Springer Verlag, 2014 **[0011]**