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PCT

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY (PCT Rule 43bis.1)

Date of mailing
(day/month/year) see form PCT/ISA/210 (second sheet)

Applicant's or agent's file reference
see form PCT/ISA/220

FOR FURTHER ACTION
See paragraph 2 below

International application No.
PCT/IL2023/051160

International filing date (day/month/year)
09.11.2023

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10.11.2022

International Patent Classification (IPC) or both national classification and IPC
INV. F01K21/02 F01K25/06

Applicant
TECHNION RESEARCH & DEVELOPMENT FOUNDATION

1. This opinion contains indications relating to the following items:

- ☒ Box No. I Basis of the opinion
- ☐ Box No. II Priority
- ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- ☐ Box No. IV Lack of unity of invention
- ☒ Box No. V Reasoned statement under Rule 43bis.1(a)(i) with regard to novelty, inventive step and industrial applicability; citations and explanations supporting such statement
- ☐ Box No. VI Certain documents cited
- ☒ Box No. VII Certain defects in the international application
- ☒ Box No. VIII Certain observations on the international application

2. FURTHER ACTION

If a demand for international preliminary examination is made, this opinion will usually be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA") except that this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notified the International Bureau under Rule 66.1bis(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of 3 months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.

For further options, see Form PCT/ISA/220.

Name and mailing address of the ISA:



European Patent Office
D-80298 Munich
Tel. +49 89 2399 - 0
Fax: +49 89 2399 - 4465

Date of completion of
this opinion

see form
PCT/ISA/210

Authorized Officer

Röberg, Andreas

Telephone No. -0



Box No. I Basis of the opinion

1. With regard to the **language**, this opinion has been established on the basis of:
- ☒ the international application in the language in which it was filed.
 - ☐ a translation of the international application into , which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1 (b)).
2. ☐ This opinion has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43bis.1(a))
3. ☐ With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, this opinion has been established on the basis of a sequence listing:
- a. ☐ forming part of the international application as filed.
 - b. ☐ furnished subsequent to the international filing date for the purposes of international search (Rule 13ter.1(a)),
 - ☐ accompanied by a statement to the effect that the sequence listing does not go beyond the disclosure in the international application as filed.
4. ☐ With regard to any nucleotide and/or amino acid sequence disclosed in the international application, this opinion has been established to the extent that a meaningful opinion could be formed without a WIPO Standard ST.26 compliant sequence listing.
5. Additional comments:

Box No. V Reasoned statement under Rule 43bis.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes: Claims	<u>2, 3, 8, 9, 11, 15-19, 24, 34-41, 45, 48</u>
	No: Claims	<u>1, 4-7, 10, 12-14, 20-23, 25-33, 42-44, 46, 47, 49-51</u>
Inventive step (IS)	Yes: Claims	<u>2, 3, 8, 9, 11, 15-19, 24, 34-41, 45, 48</u>
	No: Claims	<u>1, 4-7, 10, 12-14, 20-23, 25-33, 42-44, 46, 47, 49-51</u>
Industrial applicability (IA)	Yes: Claims	<u>1-51</u>
	No: Claims	

2. Citations and explanations

see separate sheet

Box No. VII Certain defects in the international application

The following defects in the form or contents of the international application have been noted:

see separate sheet

Box No. VIII Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:

see separate sheet

Re Item V

Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1 Reference is made to the following document:

D1 US 2013/276447 A1 (CHAIX JEAN-EDMOND [FR]) 24 October 2013
(2013-10-24)

2 Independent claims 1, 7, 13, 49, 50

2.1 The under Item VIII mentioned lack of clarity notwithstanding, the subject-matter of claims 1, 7, 13, 49 and 50 is not new in the sense of Article 33(2) PCT, and therefore the criteria of Article 33(1) PCT are not met.

2.2 Document D1 discloses all the clear features of claim 1 (the references in parentheses applying to this document) **[in the following the *italic* features relate to the use of the system and not the structure of the system per se and are thus not considered to be limiting the scope of the claim which relates to an apparatus and not a method, see also item VIII.2]:**

A system (figure 1) for storing and retrieving energy in respective charging and discharging operational modes, comprising:

at least one hot heat transfer liquid (HTL) reservoir (82) containing hot HTL;

at least one two-phase turbine (impulse wheel 42) and at least one two-phase compressor (pump 72, 108) configured for compressing compressor HTL, being the same or different than the hot HTL of the hot reservoir (same);

wherein the at least one hot HTL reservoir is selectively (i) fluidically connectable to the at least one two-phase turbine in discharging operational mode (see direct connecting line 88) or (ii) fluidically connectable or thermally couplable to the at least one two phase compressor in charging operational mode (see connecting line 80) for feeding hot HTL to the respective turbine in the discharging mode or for either heat exchanging between the compressor HTL and the HTL of the hot reservoir, the compressor HTL and the hot HTL are different and when the compressor HTL and the hot HTL reservoir are different or feeding hot HTL to the at least one compressor, when the compressor HTL and the hot HTL are the same and the compressor HTL reservoir and the hot HTL reservoir are the same, in the charging mode;

at least one condenser (see condenser 112) in fluid communication with

the turbine for receiving and condensing a working fluid (WF) coming from the turbine (the working fluid is water/steam);

at least one evaporator (the evaporation occurs in the injector 20, paragraphs [0084], [0085]) in fluid communication with the at least one compressor for receiving and evaporating WF (both WF and HTL) coming from the at least one compressor (72, 108), the at least one evaporator, being same or different element than the at least one condenser (here different because the condensation occurs in the turbine 42);

the discharging mode defining a first flow path of the WF and the charging mode defines a second flow path of the WF; and

wherein in a discharging mode the WF flows in the first flow path from the at least one condenser to one or more nozzles within the at least one turbine, the nozzles (20) being configured to induce rotation of the turbine upon discharge of fluid therefrom, to thereby mix the WF with the HTL to form a HTL/WF mixture in said one or more nozzles (paragraph [0085]), in which the WF undergoes a quasi-isothermal expansion, causing acceleration of the HTL/WF mixture and discharge of the mixture through the one or more nozzles while reducing temperature of the HTL, the HTL/WF mixture discharged out of the one or more nozzles being received in at least one first separation zone configured to separate the WF from the HTL, the HTL being recycled back to said at least one hot reservoir or to said one or more nozzles and the separated WF flowing into and received in the condenser to undergo condensation therein, the condensed WF discharged from the at least one condenser flows back to the turbine.

- 2.3 Independent apparatus claims 7, 13 relate to the same system but various different modes of operation (claim 7: charging mode, claim 13: discharging and charging). The subject-matter of these claims is thus also not novel over D1 (same cited passages).
- 2.4 Independent apparatus claim 49 relates to a similar system with also a cold HTL reservoir in a discharging mode. D1 also discloses the cold reservoir (installation 1 comprises the water tank 4 and desuperheater 28). As above the modes of operation are not defining the system per se. The subject-matter of this claim is thus also not novel over D1 (same cited passages).
- 2.5 Independent apparatus claim 50 relates to a similar system with a heat exchanger between turbine and compressor and a charging and a discharging mode. This heat exchanger is disclosed both by the cooling head 24, and the

solar energy collection means 16 of D1. As above the modes of operation are not defining the system per se. The subject-matter of this claim is thus also not novel over D1 (same cited passages).

3 Dependent claims

3.1 The present application does not meet the criteria of Article 33(1) PCT, because the additional subject-matter of the following claims (4-6, 10, 12, 14, 20-23, 25-33, 42-44, 46, 47, 51) is not new in the sense of Article 33(2) PCT.

3.2 Document D1 discloses all technical features of the following claims (paragraph [0080] - paragraph [0106]; figure 1):

3.2.1 Claims 4, 5, 20, 21: Pump 108.

3.2.2 Claims 6, 10, 22, 23: Paragraph [0093].

3.2.3 Claims 12, 25: The working fluid of D1 is water.

3.2.4 Claim 14: The evaporator/condenser arrangement 20,30.

3.2.5 Claims 26, 33: Paragraph [0087] "heat insulated enclosure 30".

3.2.6 Claim 27: Implicit features.

3.2.7 Claim 28; Glycerol (paragraph [0078]).

3.2.8 Claim 29: Refrigeration phase change material "water".

3.2.9 Claim 30: Solar collector 16.

3.2.10 Claim 31: Condenser 112, cooling tower 114.

3.2.11 Claim 32: Solar collector 16.

3.2.12 Claim 42: Embodiment of figure 1.

3.2.13 Claim 43: Evaporator nozzle 20.

3.2.14 Claim 44: Pump 72.

3.2.15 Claim 46: Implicit feature using water and HTL heated by solar collectors to evaporate the water in the evaporator 20.

3.2.16 Claim 47: It is not clear what is meant by the compressor of the HTL being different from the hot HTL. One is a device and the other a liquid. The HTL circulates in the hot HTL storage 82.

3.2.17 Claim 51: D1 discloses this system in that it comprises an electric heater (120) for heating the HTL (see embodiment of figure 1).

3.3 The combination of the features of dependent claims 2, 3, 8, 9, 11, 15-19, 24, 34-41, 45, 48 is neither known from, nor rendered obvious by, the available prior art.

4 Industrial Applicability

The industrial applicability of the present application seems to be self-evident (Article 33(4) PCT).

Re Item VII

- 1 Although claims 1, 7, 13, 49 and 50 have been drafted as separate independent claims, they appear to relate effectively to the same subject-matter and to differ from each other only in respect of the terminology used for the features of that subject-matter. The aforementioned claims therefore lack conciseness and as such do not meet the requirements of Article 6 PCT.
- 2 The features of the claims are not provided with reference signs placed in parentheses (Rule 6.2(b) PCT). What is introduced in within parenthesis in the claims is rather options or method steps.

Re Item VIII

- 1 The application does not meet the requirements of Article 6 PCT, because claims 1, 7, 11, 13, 16, 18, 19, 24, 36 - 41, 47 - 50 are not clear:
- 2 Claims 1, 7, 13, 49 and 50 are defined by operational modes of use of the system. While these features are not directly unclear or hinder the definition of the system they are also not limiting the scope of these claims. In the following these features are underlined. An apparatus claims needs to be defined by apparatus features or functional features which are clear enough to limit the apparatus itself. It seems that the scope of the independent claims of this application rather refer to a **method** than a system. These claims if defined as method type claims would be also limited by their operational features. These operational features are underlined in the following:

Claim 1:

A system for storing and retrieving energy in respective charging and discharging operational modes, comprising:
at least one hot heat transfer liquid (HTL) reservoir containing hot HTL;
at least one two-phase turbine and at least one two-phase compressor configured for compressing compressor HTL, being the same or different than the hot HTL of the hot reservoir;
wherein the at least one hot HTL reservoir is selectively (i) fluidically

connectable to the at least one two-phase turbine in discharging operational mode or (ii) fluidically connectable or thermally couplable to the at least one two phase compressor in charging operational mode for (1) feeding hot HTL to the respective turbine in the discharging mode or for (2) either heat exchanging between the compressor HTL and the HTL of the hot reservoir, the compressor HTL and the hot HTL are different and when the compressor HTL and the hot HTL reservoir are different or feeding hot HTL to the at least one compressor, when the compressor HTL and the hot HTL are the same and the compressor HTL reservoir and the hot HTL reservoir are the same, in the charging mode;
at least one condenser in fluid communication with the turbine for receiving and condensing a working fluid (WF) coming from the turbine;
at least one evaporator in fluid communication with the at least one compressor for receiving and evaporating WF coming from the at least one compressor, the at least one evaporator, being same or different element than the at least one condenser;
the discharging mode defining a first flow path of the WF and the charging mode defines a second flow path of the WF; and
wherein in a discharging mode the WF flows in the first flow path from the at least one condenser to one or more nozzles within the at least one turbine, the nozzles being configured to induce rotation of the turbine upon discharge of fluid therefrom, to thereby mix the WF with the HTL to form a HTL/WF mixture in said one or more nozzles, in which the WF undergoes a quasi-isothermal expansion, causing acceleration of the HTL/WF mixture and discharge of the mixture through the one or more nozzles while reducing temperature of the HTL, the HTL/WF mixture discharged out of the one or more nozzles being received in at least one first separation zone configured to separate the WF from the HTL, the HTL being recycled back to said at least one hot reservoir or to said one or more nozzles and the separated WF flowing into and received in the condenser to undergo condensation therein, the condensed WF discharged from the at least one condenser flows back to the turbine.

Claim 7:

A system for storing and retrieving energy in respective charging and discharging operational modes, comprising:
at least one hot heat transfer liquid (HTL) reservoir containing hot HTL;
at least one two-phase turbine and at least one two-phase compressor configured for compressing compressor HTL, being the same or different than the HTL of the hot reservoir;
the at least one hot HTL reservoir is selectively (i) fluidically connectable to the

at least one two-phase turbine in discharging operational mode or (ii) fluidically connectable or thermally couplable to the at least one two phase compressor in charging operational mode, for (1) feeding hot HTL to the respective turbine in the discharging mode or for (2) either heat exchanging between the compressor HTL and the HTL of the hot HTL reservoir;

at least one condenser in fluid communication with the turbine for receiving and condensing a working fluid (WF) coming from the turbine;

at least one evaporator in fluid communication with the at least one compressor for receiving and evaporating WF coming from the at least one compressor, the at least one evaporator, being same or different element than the at least one condenser;

the discharging mode defining a first flow path of the WF and the charging mode defines a second flow path of the WF; and

wherein in the charging mode, the WF flows in the second flow path and the at least one compressor is configured to form a compressor HTL/WF mixture and quasi-isothermally compress the WF in the mixture along a compressor flow path and to thereby heat the compressor HTL, the compressor HTL exchanges heat with the hot HTL reservoir to thereby heat the hot HTL reservoir and is cycled back to a reservoir, being the same or different than the hot HTL reservoir, or cycled within the least one compressor, the compressed WF being discharged from the at least one compressor to be received in the evaporator to undergo evaporation, the evaporated WF discharged from the at least one evaporator being directed back to the at least one compressor.

Claim 13:

A system for storing and retrieving energy in respective charging and discharging operational modes, comprising:

at least one hot heat transfer liquid (HTL) reservoir containing hot HTL;

at least one two-phase turbine and at least one two-phase compressor configured for compressing compressor HTL being the same or different than the hot HTL;

the at least one hot HTL reservoir is selectively (i) fluidically connectable to the at least one two-phase turbine in discharging operational mode or (ii) fluidically connectable or thermally couplable to the at least one two phase compressor in charging operational mode, for (1) feeding hot HTL to the respective turbine in the discharging mode or for (2) either heat exchanging between the compressor HTL and the hot HTL;

at least one condenser in fluid communication with the turbine for receiving and condensing a working fluid (WF) coming from the turbine;

at least one evaporator in fluid communication with the at least one compressor for receiving and evaporating WF coming from the at least one compressor, the at least one evaporator, being same or different element than the at least one condenser;

the discharging mode defining a first flow path of the WF and the charging mode defines a second flow path of the WF; and

wherein in a discharging mode the WF flows in the first flow path from the at least one first condenser to one or more nozzles within the at least one turbine, the nozzles being configured to induce rotation of the turbine upon discharge of fluid therefrom, to thereby mix the WF with the HTL to form a HTL/WF mixture in said one or more nozzles, in which the WF undergoes a quasi-isothermal expansion, causing acceleration of the HTL/WF mixture and discharge of the mixture through the one or more nozzles while reducing temperature of the HTL, the HTL/WF mixture discharged out of the one or more nozzles being received in at least one first separation zone configured to separate the WF from the HTL, the HTL being recycled back to said at least one hot reservoir or to said one or more nozzles and the separated WF flowing into and received in the condenser to undergo condensation therein, the condensed WF discharged from the at least one condenser streamed back to the turbine; and

wherein in the charging mode, the WF flows in the second flow path and the at least one compressor is configured to form a compressor HTL/WF mixture and quasi-isothermally compress the WF in the mixture along a compressor flow path and to thereby heat the compressor HTL, the compressor HTL being cycled back to a reservoir, being the same or different the hot HTL reservoir or to the at least one compressor, the compressed WF being discharged from the at least one compressor flows to be received in the evaporator to undergo evaporation, the evaporated WF discharged from the at least one evaporator being back to the at least one compressor.

Claim 49:

A system for storing and retrieving energy in respective charging and discharging modes, comprising:

at least one two-phase turbine and at least one two-phase compressor;

at least one hot HTL reservoir containing hot HTL and at least one cold HTL reservoir containing cold HTL, each selectively fluidically connectable to at least one compressor or the at least one turbine; at least one intermediary heat exchanger disposed in a flow path between the at least one compressor and the at least one turbine;

wherein in the charging mode, the at least one compressor is made to be

fluidically connected to the at least one hot HTL reservoir to receive hot HTL therefrom and quasi-isothermally compress a working fluid (WF) mixed with the hot HTL, such that the compressed working fluid flows through the at least one first heat exchanger to reduce its temperature and then to be mixed with cold HTL in one or more nozzles of the turbine to undergo isothermal or quasi-isothermal expansion that accelerates the HTL and working fluid mixture to produce kinetic energy convertible to electric energy, the working fluid discharged from the turbine being directed towards the at least one first heat exchanger to be heated for another cycle;

wherein in the discharging mode, the at least one compressor is configured to receive cold HTL from the cold HTL reservoir and quasi-isothermally compress working fluid mixed in the cold HTL, such that the compressed working fluid flows through the at least one first heat exchanger to increase its temperature and then to be mixed with hot HTL in the one or more nozzles of the turbine to undergo isothermal or quasi-isothermal expansion that accelerates the HTL/WF mixture to produce kinetic energy convertible to electric energy, the working fluid discharged from the at least one turbine being directed towards the at least one first heat exchanger to be cooled for another cycle.

Claim 50:

A system for storing and retrieving energy in respective charging and discharging modes, comprising:

at least one two-phase turbine and at least one two-phase compressor;

at least one hot HTL reservoir containing hot HTL and at least one cold HTL reservoir containing cold HTL, each selectively connectable to the at least one compressor/condenser or the at least one turbine;

at least one intermediary exchanger is disposed in a flow path between the at least one compressor and the at least one turbine;

wherein in the charging mode, the at least one compressor/condenser is made to be fluidically connected to the at least one hot HTL reservoir to receive hot HTL therefrom and quasi-isothermally compress and condense a working fluid in a liquid/vapor phase changing working fluid (LVPhC) mixed with the hot HTL, such that the condensed LVPhC flows through the at least one first heat exchanger to reduce its temperature and then to be mixed with cold HTL in one or more nozzles of the turbine to vaporize and undergo isothermal or quasi-isothermal expansion that accelerates the HTL and vaporized LVPhC mixture to produce kinetic energy convertible to electric energy, the vaporized LVPhC discharged from the turbine being directed towards the at least first heat exchanger to be heated for another cycle;

wherein in the discharging mode, the at least one compressor is configured to receive cold HTL from the cold HTL reservoir and quasi-isothermally condense and compress LVPhC mixed in the cold HTL, such that the condensed LVPhC flows through the at least one first heat exchanger to increase its temperature and then to be mixed with hot HTL in the one or more nozzles of the turbine to vaporize and undergo isothermal or quasi-isothermal expansion that accelerates the HTL and LVPhC mixture to produce kinetic energy convertible to electric energy, the LVPhC discharged from the at least one turbine being directed towards the at least one first heat exchanger to be cooled for another cycle.

- 3 Claims 11, 24: It is not clear what is meant by the "second heat exchanger" if by that is meant the "second counterflow heat exchanger" claims 11, 24 need to be corrected. If not the "second heat exchanger needs to be defined.
- 4 Claim 16: Similar to claim 11 the "the heat exchanger" is not previously defined. Probably what is intended is "first counterflow heat exchanger" which is defined in claim 15.
- 5 Claim 18: Similar to claim 11 the "the heat exchanger" is not previously defined. Probably what is intended is "second counterflow heat exchanger" which is defined in claim 15.
- 6 Claim 19: The features "the first heat exchanger" and "the second heat exchanger" need to be corrected to "the first counterflow heat exchanger" and "the second counterflow heat exchanger".
- 7 Claims 36 - 39 refer to "the first heat exchanger" which is not defined in claim 13. The dependency thus needs to be corrected.
- 8 Claims 36, 38, 40, 41 : The term "thermal pendulum" is not implicitly known and would need to be defined in the claim.
- 9 Claim 47: It is not clear what is meant by the compressor of the HTL being different from the hot HTL.
- 10 Claim 48: As for claim 47 this feature is not clear. It is not clear what is meant by "wherein said compressor HTL is the same as the hot HTL".