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(54) Title: CARBON-FREE POWER CONVERSION SYSTEM FOR SUPPLYING HIGH-TEMPERATURE PROCESS HEAT AND ELECTRICITY

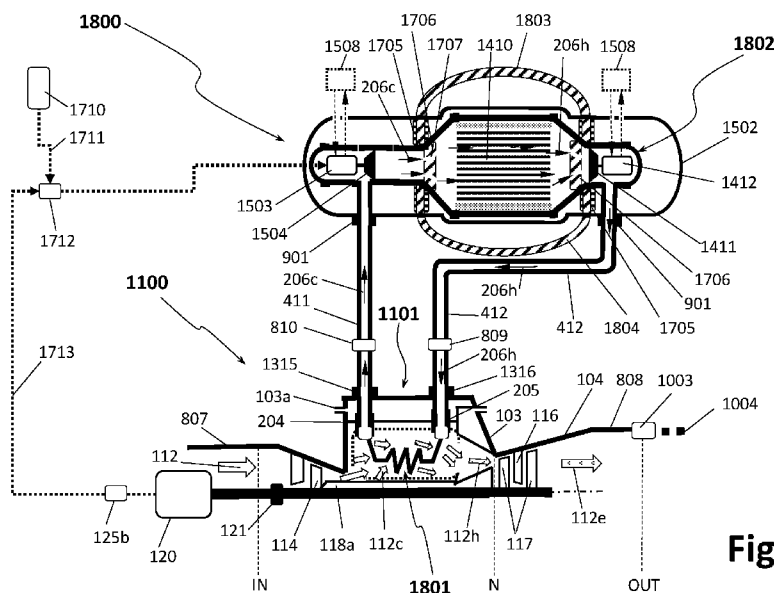


Fig. 18

(57) Abstract: Various exemplary embodiments of a power system for converting thermal energy from a heat source to electricity are disclosed. In one exemplary embodiment, the power conversion system includes a turbine-engine based on fossil-fueled aeroderivative or heavy-duty gas turbine engines coupled to electric generators, retrofitted with a heat exchanger thermally coupled to a carbon-free heat source to convert thermal energy from the carbon-free heat source to the air flowing through the engine compressor and expanding through the turbomachinery of an expander coupled to a mechanical shaft driving the engine compressor and an electric generator.

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INTERNATIONAL SEARCH REPORT

International application No.

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A. CLASSIFICATION OF SUBJECT MATTERIPC: **F02C 6/04** (2024.01); **F02C 6/18** (2024.01); **F02C 1/05** (2024.01); **F01D 13/02** (2024.01)CPC: **F02C 6/04**; **F02C 6/18**; **F02C 1/05**; **F01D 13/02**; **F05D 2220/62**

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

See Search History Document

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

See Search History Document

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

See Search History Document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2020/0173301 A1 (Rolls Royce plc) 06 April 2020 (06.04.2020) para [0030]-[0037] and fig. 1	1
Y	US 2020/0219631 A1 (Filippone) 07 September 2020 (07.09.2020) para [0024], [0035]-[0042] and figs. 1-2	1
A	US 5,967,461 A1 (Farrington) 19 October 1999 (19.10.1999) Entire document	1
A	US 2003/074895 A1 (McFarland) 24 April 2003 (24.04.2003) Entire document	1
A	US 2023/0117632 A1 (Nuovo Pignone Tecnologie - S.R.L.) 20 April 2023 (20.04.2023) Entire document	1
A	US 2021/0301720 A1 (United Technologies Corporation) 30 September 2021 (30.09.2021) Entire document	1



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

“A” document defining the general state of the art which is not considered to be of particular relevance

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“P” document published prior to the international filing date but later than the priority date claimed

“T” later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

“X” document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

“Y” document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

“&” document member of the same patent family

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2018/0051652 A1 (Filippone) 22 February 2018 (22.02.2018) Entire document	1

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1.

Group I: Claim 1, directed to a power conversion system comprising: a first expander coupled with the first compressor through a shaft; a motor; a second compressor and a second expander.

Group II: Claims 2 and 4, directed to a system comprising: a furnace; a second heat exchanger; a third heat exchanger; a second/control valve; a second power conversion system; and a fourth heat exchanger.

Group III: Claim 3, directed to a power generation and steelmaking plant system comprising: a building collocated with a steelmaking plant system; the heat exchanger comprising a primary circuit and a secondary circuit; and thermally insulated piping.

The groups of inventions listed above do not relate to a single general inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons:

SPECIAL TECHNICAL FEATURES

Group I has the special technical features of a power conversion system comprising: a first expander coupled with the first compressor through a shaft; wherein the heated first working fluid drives the first expander to rotate; a motor; a second compressor and a second expander; wherein the motor, the second compressor, the second expander, and the second electric generator are disposed within the pressure vessel, not required by Groups II-III.

Group II has the special technical features of a system comprising: a furnace coupled with the outlet of the engine chamber through piping; a second heat exchanger thermally coupled to the first heat exchanger; a third heat exchanger thermally coupled to the second heat exchanger; a second/control valve regulating the first working fluid; a second power conversion system; and a fourth heat exchanger, not required by Groups I or III.

Group III has the special technical features of a power generation and steelmaking plant system comprising: a building collocated with a steelmaking plant system; the heat exchanger comprising a primary circuit and a secondary circuit; the primary circuit being thermally coupled by a first working fluid to the thermal energy source, and the secondary circuit being thermally coupled to the steelmaking plant system by a second working fluid; and thermally insulated piping coupled to the outlet of the compressor and to the steelmaking plant system, not required by Groups I-II.

COMMON TECHNICAL FEATURES

The only technical features shared between Groups I-III is a system comprising an engine including an engine casing defining an engine chamber including an inlet and an outlet; a compressor configured to compress a first working fluid into the engine chamber; a heat exchanger configured to heat up the first working fluid compressed into the engine chamber by the compressor; a generator configured to generate electricity; an energy source configured to transfer thermal energy to a second working fluid; and piping for the first working fluid, which does not provide any contribution over the prior art as being anticipated by US 2020/0219631 A1 to Filippone (hereinafter 'Filippone').

Filippone teaches a system (See fig. 5; para [0049]-[0050]) comprising an engine (See fig. 5; para [0053]-[0054]; see shroud 5 and Rankine engine 20) including an engine casing (5 - "shroud", fig. 5) defining an engine chamber (See fig. 5; see chamber within shroud 5) including an inlet (See fig. 5; see air 15 entering shroud 5 at inlet 5a) and an outlet (See fig. 5; see air 15 exiting shroud 5 at outlet 5b); a compressor (7 - "compressor", fig. 5; para [0055]) configured to compress a first working fluid into the engine chamber (See fig. 5; para [0055]; see how compressor 7 compresses air 15 as air 15 enters shroud 5); a heat exchanger (2 - "source heat exchanger", fig. 5) configured to heat up the first working fluid compressed into the engine chamber by the compressor (See fig. 5; para [0053]; see how heat exchanger 2 transfers heat to air 15 (the first working fluid) after the air 15 is compressed and enters into shroud 5); a generator configured to generate electricity (See fig. 5; para [0055]; see electrical generator 12); an energy source (See fig. 5; para [0059]-[0060]; see heat source 3) configured to transfer thermal energy to a second working fluid (See fig. 5; para [0050]-[0051]; heat source 3 transfers heat to working fluid 30); and piping for the first working fluid (See fig. 5; see inlet conduit 36 and discharge conduit 37 for air 15).

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2024/033464

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

Accordingly, the inventions listed as Groups above lack unity of invention under PCT Rule 13 because they do not share a same or corresponding special technical feature providing contribution over prior art.

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.: 1

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.