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(54) Title: SYSTEMS AND METHODS FOR OPERATING A CLUSTER OF FLUID TURBINES

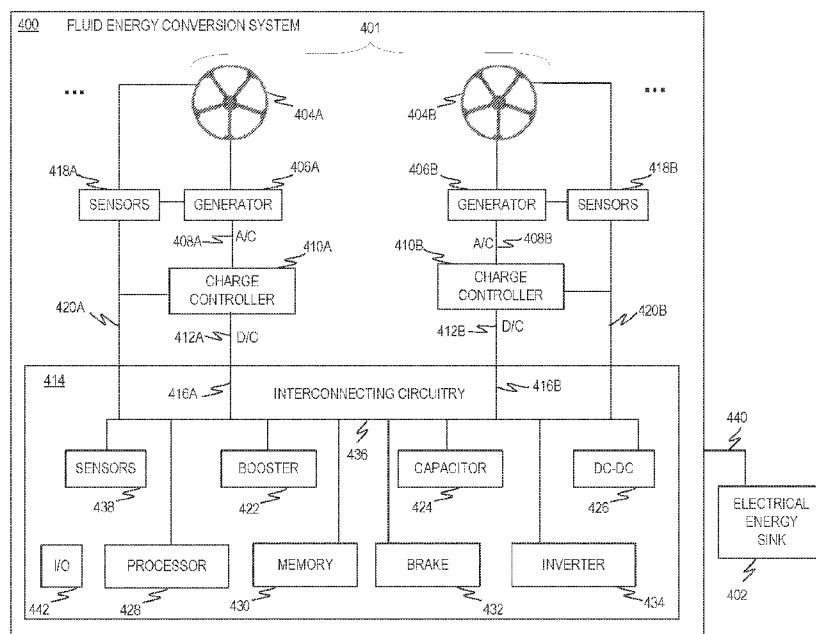


FIG. 4

(57) **Abstract:** This disclosure describes many innovations including but not limited to systems, methods, and non-transitory computer readable media containing instructions for controlling an energy generator. A system for controlling an energy generator includes a detector for sensing an indicator of electrical energy generated by the generator; an energy storage component configured, in a first mode of operation, to store energy generated during operation at a sub-threshold level insufficient for real-time supply to an electrical energy sink; an energy converter configured, in a second mode of operation, to provide energy generated during operation above the threshold level for real-time supply of energy to the electrical energy sink; and a controllable switch, electrically associated with the detector, and configured to alternately toggle between the first mode of operation and the second mode of operation based on the indicator to thereby permit energy generated at the sub-threshold level to be collected and intermittently used.





RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH,
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INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 23/65609

A. CLASSIFICATION OF SUBJECT MATTER

IPC - INV. F03D 9/11, F03D 9/25, H02P 9/04, H02J 3/32, H02J 9/06 (2023.01)

ADD. F03D 9/10, H02J 3/00, H02J 3/28, H02J 3/38 (2023.01)

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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.
X --- Y	US 2018/0340515 A1 (HITACHI, LTD.) 29 November 2018 (29.11.2018), abstract, Fig. 1-12, para. [0018]-[0137]	1, 2, 7, 10, 12, 13, 15, 17-19, 21-24
Y	US 2012/0217824 A1 (GUPTA et al.) 30 August 2012 (30.08.2012), abstract, Fig. 1-7, para. [0040]-[0076]	3, 4, 5, 6, 8, 9, 11, 14, 16, 20
Y	US 2014/0145550 A1 (HITCHCOCK et al.) 29 May 2014 (29.05.2014), Fig. 18, para. [0205]	3, 4, 5, 6, 8, 9, 11, 16, 20
A	US 2020/0106295 A1 (GENERAL ELECTRIC COMPANY) 02 April 2020 (02.04.2020), entire document	14
A	US 2018/0306169 A1 (GENERAL ELECTRIC COMPANY) 25 October 2018 (25.10.2018), entire document	1-24

☐ 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

"D" document cited by the applicant in the international application

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"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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INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 23/65609

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

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. In order for all inventions to be searched, the appropriate additional search fees must be paid.

Group I: Claims 1-24 drawn to a controllable switch for an energy generator.

Group II: Claims 25-64 drawn to an aggregated voltage controller for a cluster of fluid turbines.

Group III: Claims 65-84 drawn to applying an MPPT protocol to a generator.

--see extra sheet

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.:
1-24

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.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 23/65609

Continuation of Box No. III -- Observations where unity of invention is lacking

The inventions listed in the above-mentioned groups 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 includes the special technical features the control system comprising: a detector for sensing an indicator associated with electrical energy generated by the energy generator; at least one energy storage component configured, in a first mode of operation, to store energy generated by the energy generator during operation at a sub-threshold level insufficient for real-time supply of energy to an associated electrical energy sink; an energy converter configured, in a second mode of operation, to provide energy generated by the energy generator during operation above the threshold level for real-time supply of energy to the associated electrical energy sink; and a controllable switch, electrically associated with the detector, and configured to alternately toggle between the first mode of operation and the second mode of operation based on the indicator to thereby permit energy generated at the subthreshold level to be collected and intermittently used, not found in the other group.

Group II includes the special technical features of an aggregated voltage controller for a cluster of fluid turbines, the aggregated voltage controller comprising: at least one processor configured to: receive a target voltage level for the cluster of fluid turbines; receive via a plurality of rectifiers, each rectifier associated with a different fluid turbine in the cluster of fluid turbines, an indication of a DC voltage associated with each fluid turbine, wherein the DC voltage associated with at least one of the fluid turbines in the cluster is below the target voltage level; and based on the received indications of the DC voltage signals associated with each fluid turbine in the cluster, output a control signal to each of a plurality of DC-DC converters associated with the plurality of rectifiers, wherein each control signal is configured to regulate each DC-DC converter to produce a DC output signal at the target voltage level such that combining each DC output signal in parallel produces an aggregated DC voltage conforming to the target voltage level, not found in the other groups.

Group III includes the special technical features of a dual-channel fluid turbine controller, the dual channel fluid turbine controller comprising: at least one processor configured to: receive, via an AC channel coupled to an AC output of a fluid turbine, first signals indicating fluctuations in power generated by the fluid turbine operating beneath a grid power supply threshold; access an MPPT protocol; determine a correspondence between the first signals and a portion of the MPPT protocol; apply the portion of the MPPT protocol to a generator of the fluid turbine to generate greater power than would be generated in an absence of application of the portion of the MPPT protocol, wherein the generated power is stored as energy in a capacitor associated with the generator; receive, via a DC channel, second signals indicating a level of energy stored in the capacitor; and use the second signals to determine when to release the stored energy, not found in the other groups.

Common Technical Features:

The only technical features shared by Groups I-III are a control system for an energy generator, and below/beneath/insufficient level/threshold. However, these shared technical features do not represent a contribution over prior art, because the shared technical features are disclosed by US 2020/0166017 A1 to MHI VESTAS OFFSHORE WIND A/S (hereinafter MHI).

The only additional technical feature shared by Groups I and II are energy conversion and target level. However, this shared technical feature does not represent a contribution over prior art, because the shared technical feature is disclosed by MHI.

The only additional technical feature shared by Groups I and III are store energy, and releasing stored energy. However, this shared technical feature does not represent a contribution over prior art, because the shared technical feature is disclosed by MHI.

The only additional technical feature shared by Groups II and III are fluid turbine and processor. However, this shared technical feature does not represent a contribution over prior art, because the shared technical feature is disclosed by MHI.

MHI discloses a control system for an energy generator (para [0048]-[0052]), below/beneath/insufficient level/threshold (para [0024]), energy conversion (para [0047]), target level (para [0024]), store energy (para [0070]), releasing stored energy (para [0015]-[0016]), fluid turbine (para [0051]) and processor (para [0050]).

As the common technical feature was known in the art at the time of the invention, this cannot be considered a special technical feature that would otherwise unify the groups. Therefore, Groups I-III lack unity under PCT Rule 13.