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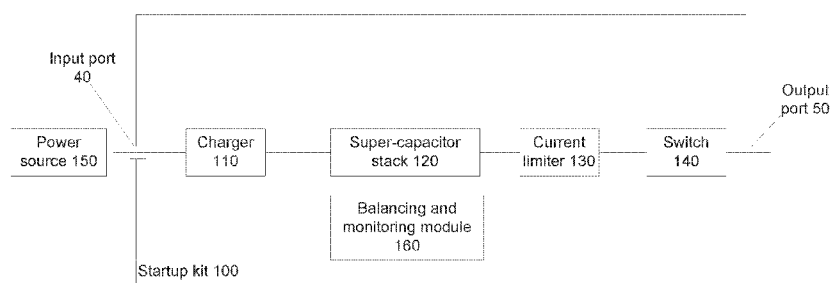


Fig. 2

(57) **Abstract:** The presently disclosed subject matter includes a startup kit for starting a platform power unit, comprising a supercapacitors stack operatively connected to a charger and a switch; the supercapacitor stack comprising a plurality of supercapacitors connected together to enable storing a certain amount of energy; the charger being connectible to an external power source and configured to receive power from the external power source and charge the supercapacitors in the supercapacitors stack; the switch is connected to the supercapacitor stack and configured to control discharge of the supercapacitors stack and to provide output current for starting the platform power unit.

STARTUP KIT FOR AN AIRBORNE AUXILIARY POWER UNIT

FIELD OF THE PRESENTLY DISCLOSED SUBJECT MATTER

This invention relates to the field of startup of airborne auxiliary power units (APUs) and engines of business and general aviation aircrafts.

5 BACKGROUND

Auxiliary power units (APUs), which are commonly found on different types of aircrafts, are used for providing the aircraft with the electrical power needed for ground operation, for starting the main engines and for supplying bleed air required for airborne environmental control systems. The APU is commonly started by a
10 dedicated start battery. Once the APU is running, it provides power (electric, pneumatic, or hydraulic, depending on the design) to start the aircraft's main engines. Start batteries can also be used for emergency operations in case normally generated power fails. At moderate temperatures, if the APU battery is properly charged and is working properly, no external ground power is needed for starting the
15 APU. Furthermore, batteries are also commonly used for engine starting in general aviation.

GENERAL DESCRIPTION

According to a first aspect of the presently disclosed subject matter there is provided a startup kit for starting a platform power unit, comprising: a
20 supercapacitors stack operatively connected to a charger and a switch; the supercapacitor stack comprising a plurality of supercapacitors connected together to enable storing a certain amount of energy; the charger being connectible to an external power source and configured to receive power from the external power source and charge the supercapacitors in the supercapacitors stack; the switch is
25 connected to the supercapacitor stack and configured to control discharge of the supercapacitors stack and to provide output current for starting the platform power unit.

According to certain embodiments of the presently disclosed subject matter the startup kit is packed in a portable case.

According to certain embodiments of the presently disclosed subject matter the case is configured with an input socket for connecting the charger to the power
5 source, and an output socket for connecting the supercapacitors pack to the power unit.

According to certain embodiments of the presently disclosed subject matter, the case further comprises a control panel for operating the startup kit and displaying information.

10 According to certain embodiments of the presently disclosed subject matter the startup kit further comprises a current limiter configured to enable control of the output current of the startup kit.

According to certain embodiments of the presently disclosed subject matter the platform power unit is any one of: an auxiliary power unit of an airborne
15 platform; a small jet engine, and an engine of a general aviation platform.

According to certain embodiments of the presently disclosed subject matter the startup kit is configured to connect to an aircraft via the aircraft's external power inlet and perform APU start.

According to certain embodiments of the presently disclosed subject matter
20 the startup kit is configured as an onboard subsystem integrated as part of an aircraft or land vehicle.

According to another aspect of the presently disclosed subject matter there is provided a method of starting a platform power unit , comprising: connecting a portable supercapacitors stack to the platform power unit; the supercapacitors stack
25 comprising a plurality of supercapacitors connected together to enable storing a certain amount of energy;

discharging energy from the supercapacitors and starting the platform power unit; and disconnecting the supercapacitor stack from the platform power unit.

BRIEF DESCRIPTION OF THE DRAWINGS

5 In order to understand the presently disclosed subject matter and to see how it may be carried out in practice, the subject matter will now be described, by way of non-limiting examples only, with reference to the accompanying drawings, in which:

Fig. 1 is external view of a case of a startup kit, in accordance with the presently disclosed subject matter;

10 **Fig. 2** is functional block diagram of a startup kit, in accordance with the presently disclosed subject matter;

Fig. 3 is a schematic illustration of an aircraft externally connected to a startup kit, in accordance with the presently disclosed subject matter; and

Fig. 4 is a flowchart exemplifying operations which are carried out, in
15 accordance with the presently disclosed subject matter.

DETAILED DESCRIPTION

 In the drawings and descriptions set forth, identical reference numerals indicate those components that are common to different embodiments or configurations.

20 As used herein, the phrase "for example," "such as", "for instance" and variants thereof describe non-limiting embodiments of the presently disclosed subject matter. Reference in the specification to "one case", "some cases", "other cases" or variants thereof means that a particular feature, structure or characteristic described in connection with the embodiment(s) is included in at least one
25 embodiment of the presently disclosed subject matter. Thus the appearance of the

phrase "one case", "some cases", "other cases" or variants thereof does not necessarily refer to the same embodiment(s).

It is appreciated that certain features of the presently disclosed subject matter, which are, for clarity, described in the context of separate embodiments, may also be provided in combination in a single embodiment. Conversely, various features of the presently disclosed subject matter, which are, for brevity, described in the context of a single embodiment, may also be provided separately or in any suitable sub-combination.

Fig. 2 illustrates a general schematic of the system architecture in accordance with an embodiment of the presently disclosed subject matter. Various modules in **Fig. 2** can be made up of any combination of one or more of software and hardware and/or firmware that performs the functions as defined and explained herein. In other embodiments of the presently disclosed subject matter, the system may comprise fewer, more, and/or different modules than those shown in **Fig. 2**.

In embodiments of the presently disclosed subject matter, fewer, more and/or different stages than those shown in **Fig. 4** may be executed. In embodiments of the presently disclosed subject matter, one or more stages illustrated in **Fig. 4** may be executed in a different order and/or one or more groups of stages may be executed simultaneously.

Bearing this in mind, attention is drawn to **Fig. 1** showing an external view of a case of a startup kit, in accordance with the presently disclosed subject matter. As mentioned above, it is common to use batteries providing electric power for the purpose of starting an APU or a General Aviation aircraft engine. However, at low temperatures, (e.g. overnight exposure of the aircraft to an ambient temperature of around -15°C and lower) the operations of the APU start battery deteriorate, and it is often unable to provide the required power for starting the APU.

There are a number of known solutions which deal with this problem, including for example: over sizing the onboard battery, preheating the battery,

removing the battery and storing it in a warm place, or using external power (e.g. by means of an external power supply cart) to start the engines/APU.

However, these solutions impose operational constraints and cause unnecessary weight increase. For example, the need to preheat the battery may lead to additional time required by operators, prior to APU start. The need for an external power source deprives the aircraft from its autonomous startup ability and requires the availability of ground services at the landing airfield. While some airfields indeed provide these services, many others do not. Furthermore, airfields which provide such services typically charge for their use. In addition, oversizing the starting battery leads to unnecessary increase in aircraft weight.

The presently disclosed subject matter includes a portable startup kit which works well at low temperatures and therefore enables the aircraft to maintain its autonomous engine start capabilities in cold weather conditions.

Fig. 1 shows an example of the external design of a case of a startup kit (or pack) as disclosed herein. Different components of the kit can be packed in case 20, which enables to easily carry the startup kit. The case 20 can be made of a hard protective material (e.g. plastic or metal). A handle 30 for easily carrying the case can be affixed to the case. The case can also comprise an input socket 40 for connecting a power inlet for the purpose of charging the startup kit and an output socket 50 (not shown - located at the covered side of the case) for connecting the startup kit to a power receiving unit such as an APU or engine. It is noted that the terms "APU" and "engine" are referred to herein in general as "platform power units".

As schematically illustrated in Fig. 3, case 20 can be positioned externally to a platform (such as an airplane or any other airborne vehicle), and can be connected to the platform's external power inlet such as a battery connector and perform the APU (or engine) start. After a successful start, the startup kit can be disconnected from the platform.

Fig. 2 is a functional block diagram of a startup kit, in accordance with the presently disclosed subject matter. Fig. 2 shows a startup kit **100** comprising charger **110**, supercapacitor-stack **120**, and switch **140**. Startup kit **100** can optionally comprise current-limiter **130**. The different components in startup kit **100** can be compactly packed in case **20** as described above.

According to the presently disclosed subject matter, the startup kit includes a supercapacitor stack **120** for storing and providing the required power for starting a respective platform power unit (e.g. APU or engine). Unlike batteries which are commonly used for starting up platform power units, the performance of supercapacitors (otherwise known as ultra capacitor or electric double-layer capacitor - EDLC) is less influenced by cold temperatures. Therefore, the presently disclosed startup kit can operate at extremely low temperatures without any need for heating. Furthermore, super-capacitors can be charged relatively fast (e.g. in a matter of a few minutes). Additionally, supercapacitors are lightweight (for example one model of the pack weighs around 7 kilograms) and thus can be carried on aircrafts of various sizes.

A supercapacitors stack **120** can comprise multiple supercapacitors which are connected together in order to provide the required energy as well as required voltage/current characteristics. The number of supercapacitors in a supercapacitors stack **120** can be adapted to provide the required current for starting a given platform power unit. For example, starting up an APU of a mid-size business jet which requires 28 volts for startup, can be accomplished with the help of a supercapacitors stack comprising an appropriate number of supercapacitors providing the required energy.

In addition, the current which is supplied by the startup kit can be controlled by configuring the connections between the capacitors as serial or parallel connections or some combination thereof.

Charger **110** is configured to receive power from some external power source **150** via input port **40** and can charge the supercapacitors in supercapacitors stack **120**.

5 Switch **140** is configured to control the discharge of the supercapacitors in stack **120**. When switch **140** is turned on, the supercapacitors are discharged and the required power is provided to the platform power unit connected to starting kit **100** via output port **50**.

Startup kit **100** (optionally within case **20**) can be carried onboard an aircraft intended to land in cold weather and be used as a portable onboard startup kit.
10 Alternatively or additionally, startup kit **100** may be kept as a portable startup kit in airports as part of ground support equipment. It may be also kept by maintenance support teams of air fleet operators.

Optionally, starting pack **100** can further comprise current limiter **130** which is configured to limit the current which is supplied by supercapacitor stack **120**. For
15 example, the resistance of the current limiter **130** can be adjustable for controlling the output current. Accordingly, supercapacitors stack **120** can be configured to provide maximal current while the current limiter can be used for adjusting the supplied current to the required amount. This configuration would allow to use startup kit **100** for starting various platform power units (and possibly to supply
20 current to other devices) where each requires a different amount of current for startup.

Startup kit **100** can further comprise a control panel comprising for example, power switch, charging indicator, indicator of charge level of capacitors and a start switch connected to switch **140** and enabling to control the discharge of the
25 supercapacitors pack.

Startup kit can further comprise a balancing and monitoring module **160** configured for evenly distributing the voltage across the different supercapacitors in the stack.

According to an alternative configuration, components of startup kit **100** are not packed inside a portable case, but are rather integrated within the aircraft as an onboard subsystem for starting a platform power unit. Such subsystems can be installed in aircrafts for providing the required current for starting a respective platform power unit, instead of or in addition to batteries, which are commonly used today. This configuration would provide an onboard solution for starting the platform power unit while overcoming the limited performance of batteries at low temperatures.

Fig. **4** is a flowchart exemplifying operations which are carried out in accordance with the presently disclosed subject matter. Fig. **4** demonstrates operating the startup kit which is described above with reference to figs. 1 to 3.

At block **401** a startup kit comprising a supercapacitors stack is connected to the platform power unit. As explained above, the supercapacitors stack comprising a plurality of supercapacitors, is connected together to enable storing a certain amount of energy (the supercapacitor stack can be charged either before or after connecting to the platform).

At block **403** the energy stored in the supercapacitors stack is discharged, starting the platform power unit. After the platform power unit is started, the startup kit is disconnected from the platform power unit. The startup kit can be then stored for example, onboard the platform (e.g. airplane) or at an airfield airport as part of ground maintenance equipment.

It is to be understood that the presently disclosed subject matter is not limited in its application to the details set forth in the description contained herein or illustrated in the drawings. The presently disclosed subject matter is capable of other embodiments and of being practiced and carried out in various ways. Hence, it is to be understood that the phraseology and terminology employed herein are for the purpose of description and should not be regarded as limiting. As such, those skilled in the art will appreciate that the conception upon which this disclosure is

based may readily be utilized as a basis for designing other structures, methods, and systems for carrying out the several purposes of the present presently disclosed subject matter.

CLAIMS:

1. A startup kit for starting a platform power unit, comprising:
a supercapacitors stack operatively connected to a charger and a switch;
the supercapacitor stack comprising a plurality of supercapacitors connected
5 together to enable storing a certain amount of energy;
the charger being connectible to an external power source and configured to
receive power from the external power source and charge the supercapacitors in the
supercapacitors stack;
the switch is connected to the supercapacitor stack and configured to control
10 discharge of the supercapacitors stack and to provide output current for starting the
platform power unit.
2. The startup kit according to claim 1 being packed in a portable case.
3. The startup kit according to claim 2 wherein the case is configured
with an input socket for connecting the charger to the power source, and an output
15 socket for connecting the supercapacitors pack to the power unit.
4. The startup kit according to any one of the preceding claims wherein
the case further comprises a control panel for operating the startup kit and
displaying information.
5. The startup kit according to any one of the preceding claims further
20 comprising a current limiter configured to enable to control the output current of
the startup kit.
6. The startup kit according to any one of the preceding claims wherein
the platform power unit is any one of: an auxiliary power unit of an airborne
platform, a small jet engine and an engine of a general aviation platform.

7. The startup kit according to any one of the preceding claims is configured to connect to an aircraft via the aircraft's external power inlet and perform APU start.

8. The startup kit according to claim 1 being configured as an onboard
5 subsystem integrated as part of an aircraft or land vehicle.

9. A method of starting a platform power unit , comprising:

connecting a portable supercapacitors stack to the platform power unit; the supercapacitors stack comprising a plurality of supercapacitors connected together to enable storing a certain amount of energy;

10 discharging energy from the supercapacitors and starting the platform power unit; and

disconnecting the supercapacitor stack from the platform power unit.

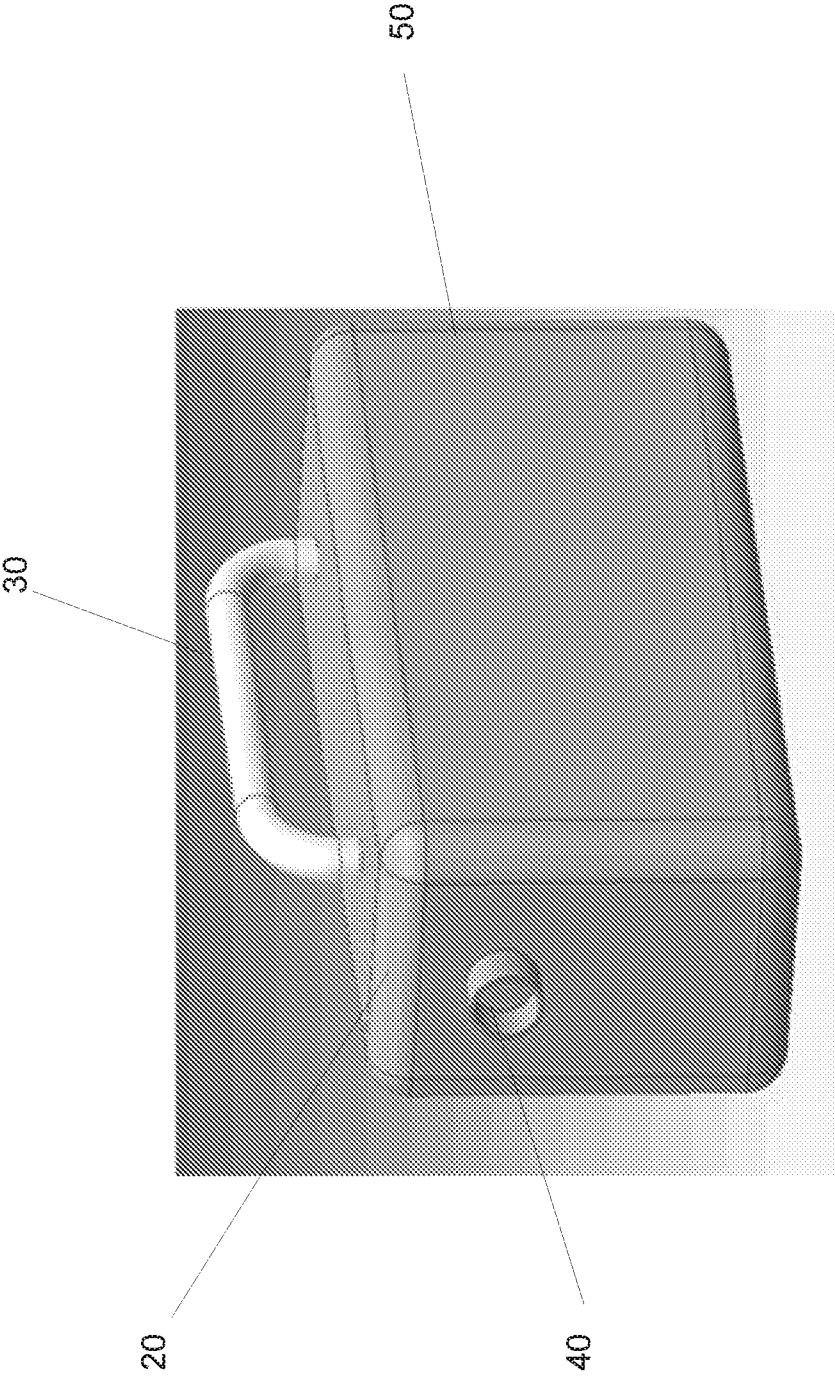


Fig. 1

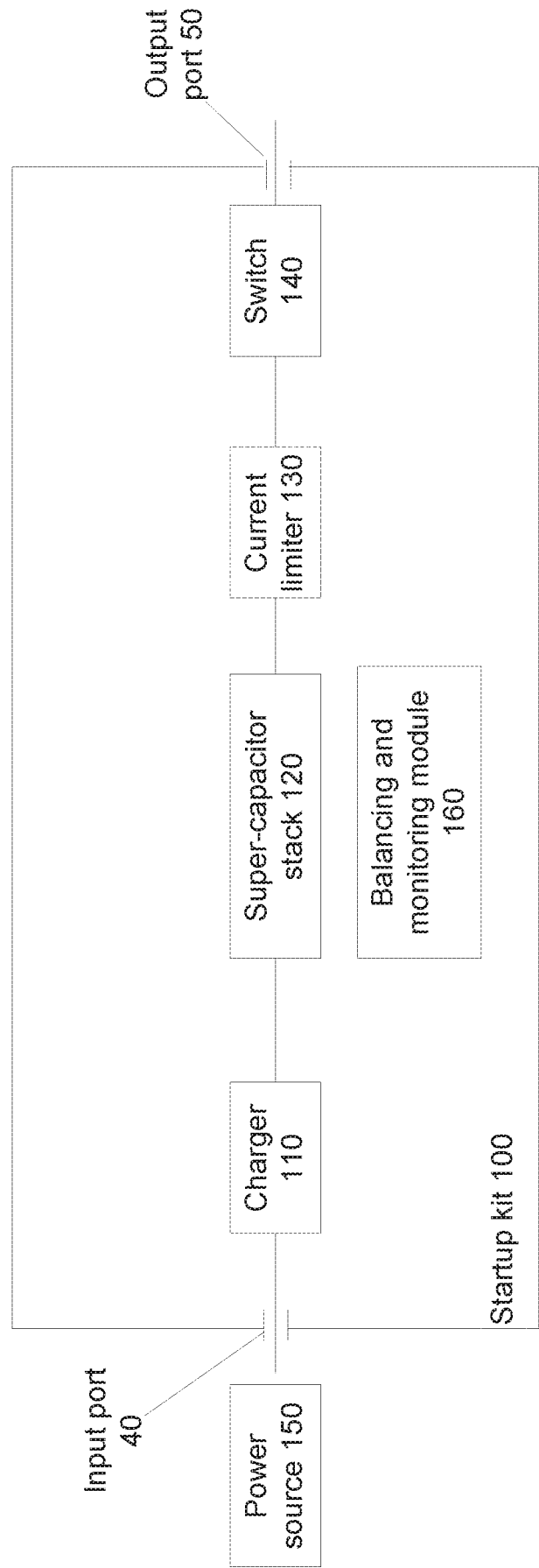


Fig. 2

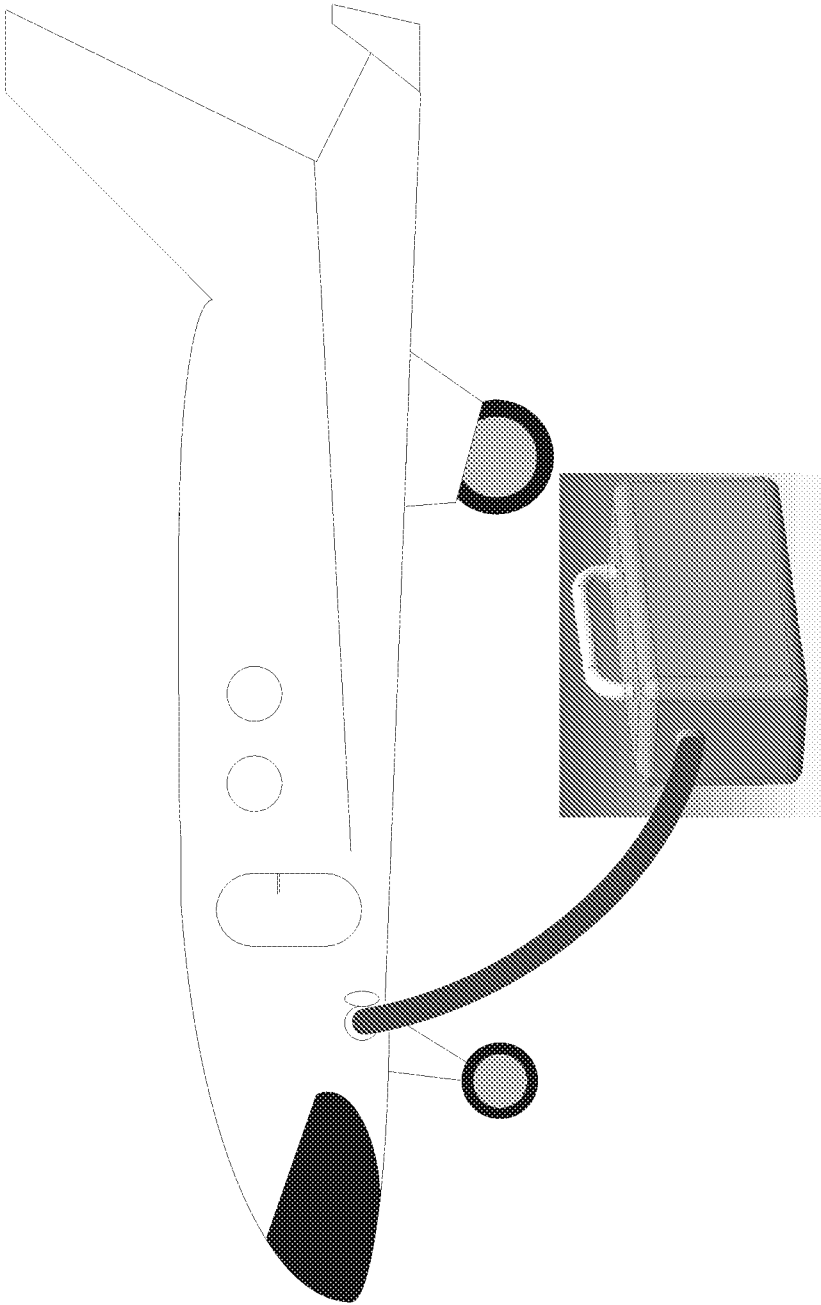


Fig. 3

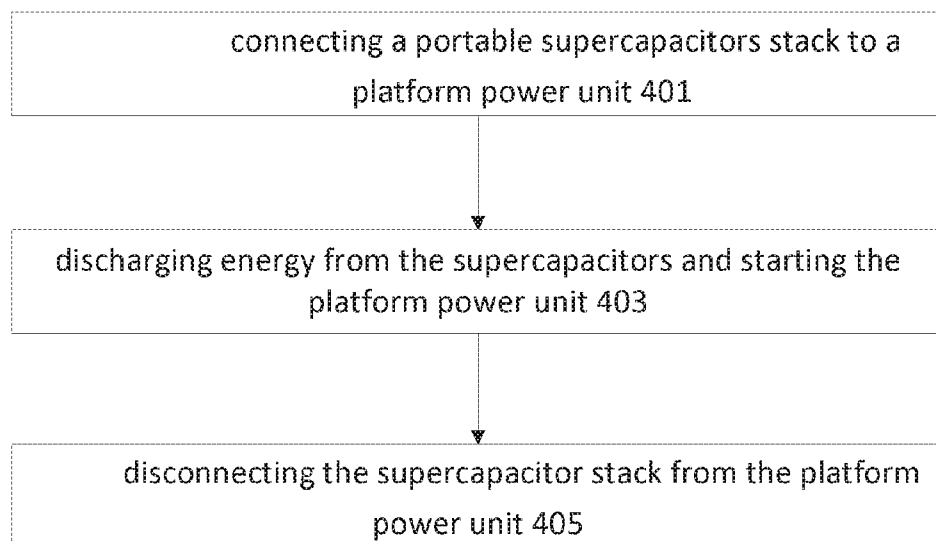


Fig. 4

INTERNATIONAL SEARCH REPORT

International application No.

PCT/IL2014/050776

A. CLASSIFICATION OF SUBJECT MATTER IPC (2014.01) H01G 11/08, B64F 1/34 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) IPC (2014.01) H01G 11/08, B64F 1/34, H01M 16/00 Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) Databases consulted: THOMSON INNOVATION, Esp@cenet, Google Patents, Google Scholar, FamPat database Search terms used: auxiliary power unit (APU), charger, starter, generator, ground power unit (GPU), start pac, Supercapacitor (SC), electric double-layer capacitor (EDLC), ultracapacitor, starter, crank		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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☒ 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 "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		
Date of the actual completion of the international search 17 Dec 2014		Date of mailing of the international search report 23 Dec 2014
Name and mailing address of the ISA: Israel Patent Office Technology Park, Bldg.5, Malcha, Jerusalem, 9695101, Israel Facsimile No. 972-2-5651616		Authorized officer COHAY Mattan Telephone No. 972-2-5651611

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