

Supply module for supplying an effector system and effector system with a supply module

5 Description

The present invention relates to a supply module for supplying a weapon system. The present invention also comprises an effector system comprising a weapon system to be supplied and the supply module. Particular preference is given to the
10 weapon system to be supplied being a laser weapon system.

In designs for high energy laser weapon systems, diode-pumped solid state lasers in the performance category of around 100 kW are frequently proposed for generating the laser radiation. The proposed high energy laser weapon systems possess laser
15 devices that typically have an efficiency of around 20%. During operation, a very high cooling capacity of 80% of the electrical power used is therefore required, wherein a stabilization of the coolant temperature precisely to a few degrees Celsius is necessary. In view of the aforementioned magnitude of the diode-pumped solid state lasers of a few hundred kilowatts, the cooling of laser devices poses a considerable
20 challenge.

It is known from the prior art that laser devices can be supplied with power and cooled with a suitably dimensioned electric generator and a sufficiently large cooling unit. The required outputs, however, result in such supply devices being extremely
25 heavy and bulky. The production of a laser weapon on a mobile carrier vehicle in particular thus becomes impossible.

Also known from the prior art is the use of electric storage batteries for supplying high energy laser weapon systems, which batteries temporarily store electrical energy for
30 operating the weapon system. Cooling can be effected by, for example, a high volume of liquid coolant, wherein the liquid coolant heats up considerably during the operation of the weapon system. However, these designs have a major disadvantage in that, after a certain operating time of the weapon system (typically lasting about

one minute), a longer period (typically around 15 minutes) is required in order to recharge the batteries and re-cool the liquid coolant. The usage time of the weapon system is thus severely limited.

- 5 DE 10 2011 116 288 A1 discloses, for example, an underwater vehicle comprising a laser effector system. Because underwater vehicles are typically already equipped with power generation and cooling systems, the laser weapon system runs off of said systems of the underwater vehicle.
- 10 DE 10 2012 000 672 A1 on the other hand discloses a laser weapon system designed for stationary operation. The aim here is to store, by means of a special arrangement of energy storage units, the energy generated by a stationary generator so that this energy can be dispensed to the weapon system in concentrated form. The aim of a distributed arrangement of the energy storage units is to avoid
- 15 transferring a heavy current.

DE 60 2004 000 303 T2 in turn discloses an electro-hydraulic unit. Here an electric motor drives a pump, by means of which fluid pressure is built up in the hydraulic system. The hydraulic pressure is then stored in an accumulator, thus providing a

20 hydraulic power reserve.

Lastly, DE 10 2008 054 264 B4 discloses a multi-functional service and test mechanism for unmanned air vehicles. The service and test mechanism includes, among other things, the possibility of supplying the air vehicle with electric power fed

25 in from outside via the power supply system of the service device.

Hence the object of the invention is to provide a supply module for a weapon system, in particular for a high energy laser weapon system, which is easily and economically manufactured and installed, lightweight, and compact, but permits a long usage time

30 of the weapon system. Another object of the invention is to provide an effector system that likewise satisfies the aforementioned features.

The object is achieved with the features of the independent claims.

Accordingly, the object is achieved by a supply module that can be used for supplying a weapon system. The supply module of the invention comprises an electric storage device and also a thermal storage device. The electric storage device is in particular designed for storing electrical energy over a long period. The thermal storage device is configured for storing a coolant. According to the invention, further provision is made such that at least one electrical connection is present, via which electrical energy can be transferred from the electric storage device to the effector system. A thermal connection in turn permits the transfer of the coolant from the thermal storage device to the effector system. Such an arrangement is in particular advantageous if the weapon system is to be supplied by mobile means. High-performance supply devices are not needed in this case. According to the invention then, provision is made such that the supply module for supplying the weapon system is interchangeable.

The invention further relates to an effector system that comprises at least one weapon system to be supplied and at least one supply module as described previously or according to one of the developments presented further below. The weapon system to be supplied is in particular a laser weapon. The effector system further comprises at least one receiving device that is rigidly attached to the weapon system. The supply module can be introduced into the receiving device so that the weapon system can be supplied with electric power and with the coolant from the supply module. Hence provision is preferably made such that the receiving device is connected to the weapon system via a fluid conduit and via an electric conduit. In particular this connection can be rigidly configured, since the supply module is preferably connectable to the receiving device via the electrical connection and the thermal connection so that electric power and coolant can be drawn from the supply module. Hence the supply module for supplying the weapon system is advantageously interchangeable so that, after an operation time in which the reserves of the supply module are expended, the weapon system is only inoperable for the time required to change the supply module. In particular the supply module is in turn reusable once its reserves have been replenished.

Preferred developments of the invention are the subject matter of the subordinate claims.

Provision is preferably made such that the electrical connection and/or the thermal connection of the supply module comprise(s) a quick coupler. The supply module can thus be quickly, easily, and securely connected to the weapon system in order to supply the weapon system with coolant and electric power. The quick couplers of the electrical connection or of the thermal connection can be brought into contact with the weapon system either jointly or independently of one another.

The electric storage device is advantageously configured in such a way that the latter has a specific power of at least 1000 Watts per kilogram (W/kg). The electric storage device in particular has a specific power of at least 3000 W/kg. Alternatively or additionally, provision is made such that the specific energy of the electric storage device is at least 100 Watt-hours per kilogram (Wh/kg). The specific energy is in particular at least 120 Wh/kg. With such an energy supply, in particular a maximum operating time of the weapon system with minimum weight and minimum volume is achievable.

The electric storage device can advantageously ensure a sustained supply of power to the weapon system for an operating time of at least 100 seconds. Particular preference is given to the electric storage device being able to sustain an operating time of at least 150 seconds. Hence the weapon system is available long enough to counter threats.

Preference is given to the electric storage device comprising lithium-iron phosphate rechargeable batteries. Such batteries have a longer useful life, a low self-discharge, and can be recharged often. Hence such batteries are very well-suited for use in weapon systems. In particular provision is made such that the lithium-iron phosphate batteries can be recharged at least 1000 times.

In an advantageous embodiment, the thermal storage device comprises a latent heat accumulator. The latter is in particular constructed in such a way that the liquid

coolant contains a material which, as heat is absorbed, undergoes a phase transition without undergoing a temperature change. Particular preference is given to such a material containing paraffin so that a cooling of the weapon system is effected by the paraffin transitioning from a solid state to a liquid state. Particular preference is given to the liquid coolant comprising an aqueous emulsion in which are present paraffin-filled plastic capsules. The plastic capsules are in particular 5 μm in diameter. Such a liquid coolant is very advantageous for cooling laser systems because this fluid always maintains its temperature, while the cooling is effected by the phase transition of the paraffin.

In a particularly advantageous manner the coolant has a latent heat capacity of at least 20 kilojoules per kilogram (kJ/kg). In particular the coolant has a latent heat capacity of at least 40 kJ/kg. A phase transition temperature is in particular defined at 20°C. Such values enable an advantageous cooling of laser weapon systems in such a way that the generated heat is effectively dissipated.

Preference is given to the effector system of the invention being configured in such a way that a loading device is present. The loading device can preferably be a crane. The supply module can be introduced into the receiving device and/or removed from the receiving device by means of the loading device. Owing to the advantageous loading device, the supply module is quickly and easily interchangeable so that only a short idle time is necessary, during which the weapon system to be supplied is inoperable.

In another preferred embodiment of the effector system of the invention, at least two receiving devices are present so that it is possible to switch between the receiving devices for supplying the weapon system. In this manner the weapon system can be operated continuously, since it is possible to switch from a first supply module to a second supply module when the first supply module is expended. Because the supplying of the weapon system is ensured by the second supply module, the first supply module can then be removed from the receiving device. A third supply module can be introduced into the receiving device of the first supply module so that, after the second supply module is expended, it is possible to switch to the third supply

module. It is obvious that a continuous operation of the weapon system is enabled in this manner.

Lastly, provision is preferably made such that the effector system comprises a platform. Preference is given to mounting the weapon system as well as the at least one receiving device on the platform. The platform is advantageously configured as a mobile platform, in particular as a land vehicle or as a watercraft. This has the advantage that the weapon system can always be moved to a place where it is needed.

The invention will now be described in detail with the aid of exemplary embodiments, which refer to the appended drawings. Shown are:

Figure 1 a schematic view of the supply module according to an exemplary embodiment of the invention, and

Figure 2 a schematic view of the effector system according to an exemplary embodiment of the invention.

Figure 1 shows a supply module 1 according to an exemplary embodiment of the invention. The supply module 1 comprises an electric storage device 2 and also a thermal storage device 3. The electric storage device 2 is connected to an electrical connection 5, which in particular is designed as a quick coupler. The energy of the electric storage device can be dispensed via the electrical connection 5. Also present is a thermal connection 4, which is likewise designed as a quick coupler. A coolant stored in the thermal storage device 3 can be dispensed via the thermal connection 4.

Preference is given to the module consisting of a cylindrical steel or aluminum container 0.5 m in diameter and 1.5 m in length. In this container is housed the electric storage device 2 in the form of electric storage batteries, whereas the thermal storage device 3 comprises a liquid coolant, which in turn comprises a latent heat accumulating material.

Preference is given to storing the electrical energy by means of lithium-iron phosphate rechargeable batteries, which have a specific power of 3000 W/kg and a specific energy of 120 Wh/kg. With the electric storage device 2, 50 kW of power can be dispensed for 140 seconds, the electric storage device having a weight of only 16.7 kg and a volume of 50 l.

The thermal storage device 3 comprises a coolant, which comprises an aqueous emulsion of paraffin-filled plastic capsules. Preference is given to the plastic capsules having a dimension of ca. 5 μm . This emulsion possesses a latent heat capacity of 40 kJ/kg at a predefined phase transition temperature. This phase transition temperature is in particular 20°C. During a cooling process by the aqueous emulsion, this temperature remains constant because the absorbed heat effects a phase transition of the paraffin from solid to liquid. The thermal storage device has in particular a weight of 100 kg and a volume of 100 l. 4 MJ of cooling energy can thus be provided.

According to the exemplary embodiment, the total weight of the supply module is about 170 kg. The supply module 1 is thus very easy to manipulate. The supply module can in particular be introduced into a receiving device 8, as shown in Figure 2.

Figure 2 shows an effector system 6, which comprises a weapon system 7 to be supplied. The weapon system 7 is in particular a high energy laser weapon system. The weapon system 7 is connected to the receiving device 8 by means of a fluid conduit 11 and by means of an electric conduit 12. The previously described supply module 1 can be introduced into the receiving device 8. The receiving device 8 also makes it possible to connect the electrical connection 5 to the electric conduit 12 via an electric coupling element 10, and thus to supply the weapon system 7 with electrical energy. The receiving device 8 furthermore makes it possible to connect the thermal connection 4 of the supply module 1 to the thermal conduit 11 via a thermal coupling element 9, and thus to supply the weapon system 7 with the coolant.

For supplying the weapon system 7, within said weapon system 7 provision is made of an electric control unit, which controls the supplying of the weapon system 7 with power from the electric storage device 2. Also present is a cooling pump, which
5 draws the coolant from the thermal storage device 3 and feeds the coolant back into the thermal storage device 3. Between withdrawal and in-feeding of the coolant, the coolant is used to absorb and discharge the waste heat of the weapon system 7.

The weapon system 7 has in particular an output of 50 kW, wherein an optical power
10 output of 10 kW can be generated. The weapon system thus has an efficiency of 20%. The supply module 1 according to the aforementioned exemplary embodiment thus makes it possible to supply the weapon system 7 for an operating time of at least 100 seconds.

As soon as the supply module 1 is expended, the latter can be removed from the
15 receiving device 8 so that another supply module 1 can be inserted therein. In this manner the weapon system 7 is operational again within a very short time span such that the effector system 6 is characterized by a high rate of availability. The spent supply module 1 can then be prepared for re-use by a recycling device, wherein the
20 electric storage device is recharged and the coolant of the thermal storage device is restored to a ready-to-cool state by another phase transition.

The effector system 6 advantageously has at least two receiving devices 8. Thus it is possible to remove a supply module 1 from one of the receiving devices 8 while
25 another supply module 1 in the other receiving device 8 is supplying the weapon system 7. This means that replacement of the supply modules 1 is possible while the weapon system 7 is in operation. The weapon system 7 can therefore be operated in a continuous mode, which is not possible or only possible with considerable effort in prior art systems. Lastly, the effector system 6 is affixed to a platform 13. This means
30 that both the weapon system 7 and the receiving device 8 are mounted on the platform 13. Preference is given to designing the platform 13 as a mobile platform, in particular as a land vehicle or as a watercraft. Because the effector unit 6 is rapidly

and easily moved to a location where it is needed, the platform 13 enables a highly varied and diverse use of the weapon system 7.

List of reference signs

	1	Supply module
	2	Electric storage device
5	3	Thermal storage device
	4	Thermal connection
	5	Electrical connection
	6	Effector system
	7	Weapon system
10	8	Receiving device
	9	Thermal coupler
	10	Electric coupler
	11	Thermal conduit
	12	Electric conduit
15	13	Platform

Claims

1. Supply module (1) for supplying a weapon system (7), comprising
 - an electric storage device (2),
 - 5 – a thermal storage device (3), wherein the thermal storage device (3) stores a coolant, and
 - at least one electrical connection (5) via which energy can be transferred from the electric storage device (2) to the effector system (7), and
 - at least one thermal connection (4) via which the coolant can be transferred
 - 10 from the thermal storage device (2) to the effector system (7),
 - wherein the supply module (1) is interchangeable.
2. Supply module (1) as in claim 1, characterized in that the electrical connection (5) and/or the thermal connection (4) comprise(s) a quick coupler.
- 15 3. Supply module (1) as in one of the previous claims, characterized in that the electric storage device (2) has a specific power of at least 1000 W/kg, in particular of at least 3000 W/kg and/or a specific energy of at least 100 Wh/kg, in particular of at least 120 Wh/kg.
- 20 4. Supply module (1) as in one of the previous claims, characterized in that the electric storage device (2) is able to ensure a sustained supply of power to the weapon system for an operating time of at least 100 seconds, in particular of at least 150 seconds.
- 25 5. Supply module (1) as in one of the previous claims, characterized in that the electric storage device (2) comprises lithium-iron phosphate rechargeable batteries.
- 30 6. Supply module (1) as in one of the previous claims, characterized in that the thermal storage device (3) comprises a latent heat accumulator.
7. Supply module (1) as in claim 6, characterized in that the coolant has a latent heat capacity of at least 20 kJ/kg, in particular at least 40 kJ/kg.

8. Effector system (6), comprising

- at least one weapon system (7) to be supplied, in particular a laser weapon,
- at least one interchangeable supply module (1) as in one of the previous claims, and

- 5
- at least one receiving device (8), which is rigidly connected to the weapon system (7), wherein
 - the supply module (1) can be introduced into the receiving device (8) in order to supply the weapon system (7) with electric power and with coolant from the supply module (1).

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9. Effector system (6) as in claim 8, characterized by a loading device, in particular a crane, wherein the supply module (1) can be introduced into the receiving device (8) and/or removed from the receiving device (8) by means of the loading device.

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10. Effector system (6) as in claim 8 or claim 9, characterized by at least two receiving devices (8), wherein for supplying the weapon system (7) it is possible to switch between the receiving devices (8) so that the weapon system (7) can be operated continuously.

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11. Effector system (6) as in one of claims 8 through 10, characterized by a platform (13) on which the weapon system (7) and the receiving device (8) are mounted, wherein the platform (13) is configured as a mobile platform.

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