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2018201751 12 Mar 2018

Abstract

The present invention relates generally to drive systems having at least one electric motor, which can be powered by means of power electronics that can be connected to a voltage source via a DC voltage circuit, and an energy storage apparatus for temporarily storing energy fed back from the electric motor. In this case, the invention relates particularly to an energy storage apparatus for such a drive system, having at least one electrical storage block, a DC chopper for connecting said DC voltage circuit to the internal voltage circuit of the storage block, and a control unit for controlling the DC chopper. According to the invention, the energy storage apparatus is distinguished in that the DC chopper is in bidirectional form, the control unit has delivery and feed control means for actuating the DC chopper both for delivering and for feeding current from and to the storage block, wherein said DC chopper, the storage block and the control unit are combined to form an energy storage unit with a common housing that holds said components and the outside of which is provided with 2 connections for connection to the DC voltage circuit.

Figure 4

2018201751 12 Mar 2018

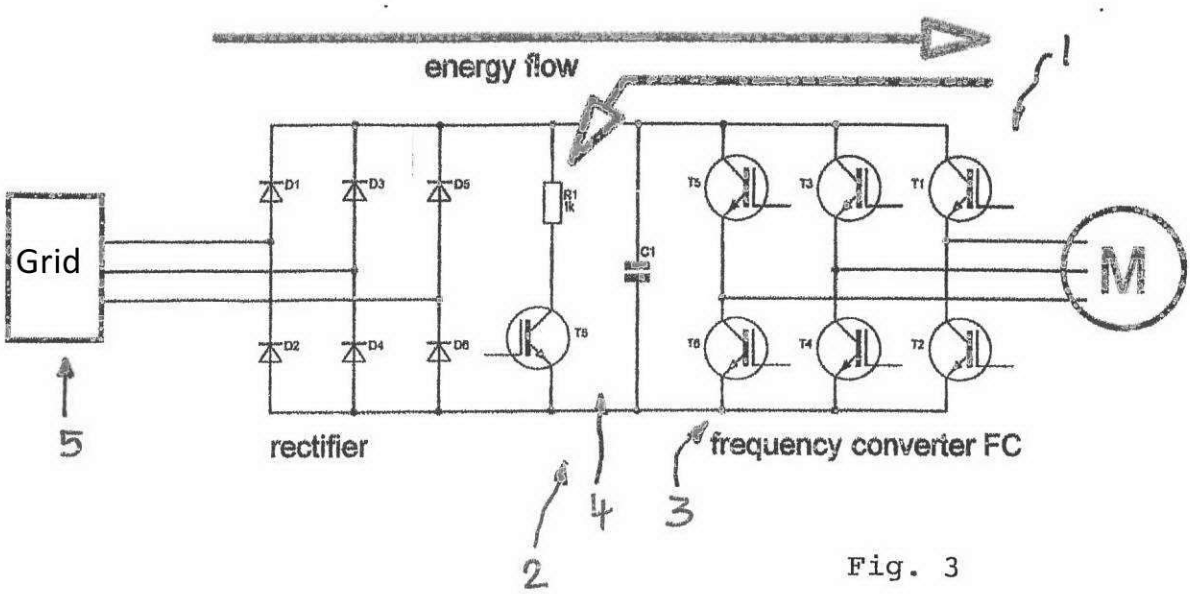

Fig. 3

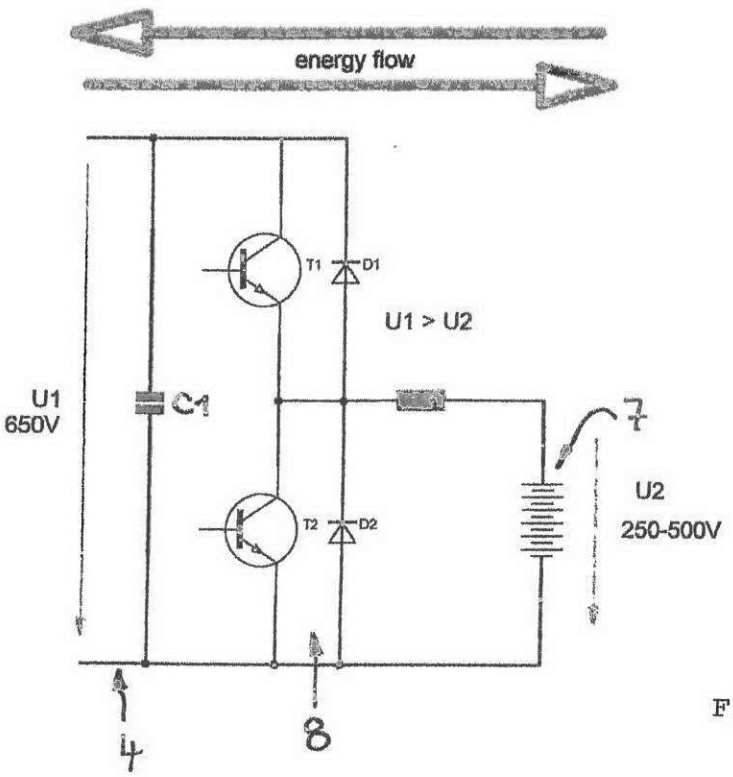

Fig. 4

2018201751 12 Mar 2018

Electric drive system and energy storage apparatus for same

Technical Field

The present invention relates generally to drive systems having at least one electric motor which can be fed via power electronics which can be connected via a DC circuit to a voltage source and having an energy storage apparatus for buffering energy fed back from the electric motor. In this respect, the invention in particular relates to such an energy storage apparatus for connecting to a DC voltage circuit of power electronics, having at least one electrical storage block, having a DC/DC converter for connecting the named DC voltage circuit to the internal voltage circuit of the storage block and having a control unit for controlling the DC/DC converter. Such electric drive systems can be used with lifting apparatus, in particular cranes such as container bridge cranes or construction machinery such as concrete-mixer vehicles, but generally also with other mobile machinery or also machinery connected to the grid.

Background

To save energy more and more drives which were previously driven mechanically or hydraulically are being electrified to be able to utilize the better efficiency of electric motors. Such an electrification is also underway in construction machinery such as concrete mixer vehicles, earth-moving machinery and mining machinery such as surface miners or cranes such as container bridge cranes, even though electric drives and their components can be used less easily than with work machines used in buildings due to rough working conditions such as dust exposure, powerful vibrations and the like.

In order not only to be able to utilize the better efficiency of electric motors themselves in such electric drive systems, but also furthermore to be able to save energy, electrical energy is buffered when it arises in the work cycle, for example on a lowering of loads or on braking, and is released again when energy is required, for example on the raising of loads, on accelerating, etc. The storage of the energy is sensibly brought about electrically here, for which purpose capacitors, in particular dual-layer capacitors, or other battery systems or rechargeable batteries are suited.

If such dual-layer capacitors are used as energy stores, so-called DC/DC converters or DC/DC transformers are required since the voltage over a dual-layer capacitor varies in dependence on a filling level. The named DC/DC transformer connects the dual-layer capacitor storage module to the drive elements or to the frequency inverter normally connected thereto and ensures the exchange of energy. Such DC/DC transformers or DC/DC converters designate an electric circuit which can convert a DC voltage supplied at the input into a DC voltage having a higher, lower or inverted voltage level and which is able to transfer energy from the high voltage level into the lower voltage level, for example to charge the energy storage block, and likewise to transfer energy in the other direction, i.e. to withdraw it, or to transfer it from the storage block into the DC voltage circuit of the drive system.

The linking of such an energy storage apparatus having a dual-layer capacitor to the respective drive system is, however, more or less complex and/or expensive since the individual modules of such an energy storage apparatus typically have to be laboriously configured together and have to be adapted to the framework conditions of the drive system, for example to its electric motor and power electronics. In this respect, a user or an application engineer is as a rule forced to deal with the complex internal routines in the energy store and in the DC/DC converter to be able to make the necessary designs with respect to the modules and to the internal operation. In addition, there is cabling work, which is more or less complex and/or expensive depending on the drive and the used unit, including high-current lines, bus wiring and SPS signals. At the same time, care must be taken with the initially named used unit that the energy storage apparatus has to withstand the rough operating conditions such as dust exposure and impact loads and vibration loads.

The term ‘comprise’ and variants of the term such as ‘comprises’ or ‘comprising’ are used herein to denote the inclusion of a stated integer or stated integers but not to exclude any other integer or any other integers, unless in the context or usage an exclusive interpretation of the term is required.

2018201751 12 Mar 2018

Any reference to publications cited in this specification is not an admission that the disclosures constitute common general knowledge in Australia or another country.

Summary of the Invention

The present invention provides an improved energy storage apparatus of the initially named kind as well as an improved drive system having such an energy storage apparatus, that avoids the disadvantages of the prior art and further develops the latter in an advantageous manner. The linking of the energy storage apparatus to a respective drive system is, in particular, dramatically simplified and in this respect the buffering and subsequent output of the electrical energy into and out of the energy store is nevertheless designed efficiently and reliably.

The present invention relates to an energy storage apparatus in accordance with statement number 1 and a drive system having such an energy storage apparatus in accordance with statement number 18. The use of such a drive system in a lifting apparatus in accordance with statement number 21 and in a construction machine in accordance with statement number 22 is furthermore a subject of the invention.

It is therefore proposed to combine the electric components of the energy storage apparatus to a plug-and-play module which can be simply connected by user in the manner of a black box to the power electronics or to the DC voltage circuit for supplying the drive system and which itself adapts to the circumstances of the system environment or carries out the required control adaptations. In accordance with the invention, the energy storage unit is characterized in that the DC/DC converter is bidirectional, the control unit has output and feed control means for controlling the DC/DC converter both on the outputting of power from the storage block to the DC voltage circuit and on the feeding of power from the DC voltage circuit into the storage block, and the named DC/DC converter, the storage block and the control unit are combined into an energy storage unit having a common housing in which the DC/DC converter, the storage block and the control unit are received and at whose outer side two connections are provided for connecting to the DC voltage circuit.

Both the feed and the output of power into or out of the storage block therefore take place via the DC/DC converter which controls both the power output and the feed so that a simple link to the DC voltage circuit of the drive system is possible. In this respect, the energy storage apparatus forms an integral overall system which combines the participating and required components in a single housing into which the control for the energy management is also installed. Only the two connections present at the outer housing side essentially have to be connected to the DC voltage circuit of the drive system, wherein the control unit in the interior of the housing of the energy storage apparatus adapts the required control and regulation parameters to the drive system.

The storage block of the energy storage apparatus can in particular comprise at least one capacitor, preferably in the form of a dual-layer capacitor, for energy storage, wherein in principle, however, at least one battery or rechargeable battery can also be provided in addition or alternatively to such one or more capacitors.

To avoid thermal problems of the energy storage apparatus, the at least one storage block and/or the DC/DC converter and/or the control unit can be connected in the interior of the common housing to a cooling circuit which can preferably have coolant connections at the housing for connection to an external cooling circuit to lead the heat entering into the coolant out of the storage block and/or the DC/DC converter and/or the control unit from the housing and to be able to output it externally. To allow a simple assembly, the named coolant connections can be configured as pluggable so that only the coolant lines of the external cooling circuit have to be connected to the housing of the energy storage apparatus.

The internal and/or external cooling circuit and its components such as coolant circulators, cooling air fans, switchover valves, flow controllers and the like are controlled by the control unit in the interior of the energy storage apparatus in dependence on the temperature, in particular in dependence on the temperature of a component in the interior of the housing of the energy storage apparatus and/or on an environmental temperature. For this purpose, at least one temperature sensor can be provided and can be connectable to the control unit, said temperature sensor

2018201751 12 Mar 2018

measuring the named component temperature and/or environmental temperature and/or the temperature of the housing interior. Alternatively or additionally, the control unit can be connectable to a flowmeter to be able to regulate the flow quantity of the cooling medium.

To be able not only to simply plug the coolant lines to the housing, the electric connections and/or the signal connections of the energy storage apparatus can also be formed as pluggable or as plugs at the outer side of the housing so that the corresponding power lines or signal lines only have to be plugged in.

To allow a simple handling and a simple transport of the energy storage apparatus, the housing into which the components of the module are integrated can be formed as divisible and can comprise a plurality of housing parts which can be put together to form a common housing into which at least the DC/DC converter, the storage block and the control unit are integrated. Different electrical components which can be connected to one another by releasable connection means, in particular plug-in contacts, on the putting together of the housing parts can be accommodated in the different housing parts. For example, plug connection parts can be attached to the interfaces of the housing parts or elsewhere such that, on the putting together or joining together of two housing parts, the plug-in connections are automatically also closed or come into engagement to connect together the electronic components which are accommodated in the two housing parts.

To ensure a secure, safe use of the energy storage unit, a warning signal device can be provided in a further development of the invention to output a warning signal when the energy storage unit is still charged with energy and in this respect voltage can still be applied at the outer connection contacts and thus a possible dangerous potential is present. The warning signal device can, for example, be visually configured and can provide a warning signal visible from the outside, but can optionally also work acoustically or in another manner.

Alternatively or additionally to such a warning signal device, an electrical disconnect switch can advantageously also be provided for disconnecting the storage block and/or for deenergizing the connections at the housing, wherein the named disconnect switch can be formed internally or in the interior of the housing of the energy storage unit as a disconnect circuit. The connections led out of the energy storage system can be deenergized voltage-wise with the aid of such an electric disconnect switch, whereby the danger potential is considerably reduced.

Alternatively or additionally, the energy storage apparatus can also comprise a preferably integrated discharge circuit which can advantageously be actuable from the outside or can convert the energy still contained in the storage block into heat on a command from the outside. Accordingly, the storage block can be discharged by a control signal which can be given to the energy storage unit from the outside, for example wen the energy storage apparatus should be decoupled from the drive system.

The housing can advantageously be formed in a sufficiently high IP safety class which allows the use of the storage system outdoors. The energy storage apparatus is advantageously mechanically configured such that it can also be used under high vibration loads such as occur with mobile work machines such as construction machinery and cranes or by a correspondingly strong design of the housing and/or a damping embedding of the electrical components in the housing and/or a suitable design of the electrical components themselves.

The control apparatus integrated into the energy storage unit can generally have different designs or can implement differing operating modes. The control apparatus is generally adapted to the specific properties of the storage elements of the at least one storage block in an advantageous further development of the invention and contains control means for carrying out the energy management in accordance with the specific properties of the named storage elements.

To be able to efficiently control the efficient use of the buffered energy and its feeding back into the drive system or the charging of the storage block, the control unit integrated into the energy storage unit can also determine information or operating parameters relating to the state of the energy storage unit, in particular of the stor-

2018201751 12 Mar 2018

age block and/or for external use. The control system can, for example, comprise control means for determining an energy index and for providing and/or transmitting this energy index to a higher-ranking control, wherein the named energy index represents the energy available in the store.

In accordance with another advantageous further development of the invention, the integrated control apparatus can also process information coming from the outside and/or can convert control commands, for example such that the control apparatus comprises control and/or regulation means for the DC/DC converter which means, in response to a control signal, convert power values definable from the outside for the charging and/or discharging by desired value default for the regulation of the DC/DC converter.

Alternatively or additionally, the control system can be supplied from the outside with configurable parameters and can carry out a characteristic controlled operating mode on the basis of these configurable parameters fed in from the outside.

In an advantageous further development of the invention, the integrated control apparatus can comprise power control means for the regulation and/or control and/or for limiting the maximum transferable powers. Alternatively or additionally, the integrated control apparatus can comprise voltage regulation and/or control means for regulating or controlling the output voltage of the energy storage unit.

The energy storage apparatus advantageously comprises at least one voltage sensor which measures the voltages at the input and/or over the storage block. In conjunction with the previously named control or regulation means, the named voltage signal can be used to regulate the output voltage, but also to transmit corresponding measured values of the current and voltage via a communication connection to an external and/or higher-ranking control apparatus.

In an advantageous further development of the invention, the modular energy storage unit cannot only be used alone, but can rather be connected to a plurality of such energy storage units. At least two, but also more than two, energy storage units can in particular be connected in parallel, wherein in a further development of the invention a plurality of such energy storage units can be connected directly in parallel with the outwardly leading power connections, i.e. plus to plus and minus to minus. The control apparatus of the or each module is in this respect advantageously configured such that it supports such a parallel connection.

The energy storage units can in particular be equipped with a communication link which allows a communication of the energy storage units among one another or a communication of the integrated control apparatus among one another. The named communication apparatus can, for example, comprise a bus system via which the energy storage units connected in parallel can communicate with one another.

In a further development of the invention, the control apparatus of the energy storage units is provided with control means or regulating means which automatically adjust all the storage blocks to a uniform energy amount with a plurality of energy stores connected in parallel or control them accordingly.

To allow a simple linking to the drive system even on a use of a plurality of energy storage units, the plurality of energy storage units can be connected among one another to a further electric line which leads to the connection of the respective internal storage block.

On a connecting together of a plurality of energy storage units, their control apparatus can interact with one another in different manners. For example, the control apparatus can act as peers with one another and can each be directly linked to a higher-ranking control, for example via a control bus.

In an alternative further development of the invention, the control apparatus of the energy storage units coupled to one another can also act with one another in a hierarchical manner, in particular such that a control apparatus of an energy storage unit forms a higher-ranking master unit and the control apparatus of the remaining energy storage units form slave units. The master unit defines conditions and/or direct control commands for the other slave units which are then carried out in a corresponding dependency. The control apparatus acting as a master unit can in particular communicate with a higher-ranking control, whereas the control apparatus acting as a slave unit can only communicate with the named master unit. The module defined as the master unit also determines and communicates the desired value defaults for the power regulation and/or other control parameters for the other modules defined as slave units.

The control apparatus acting as a master unit can advantageously have an interface for all common industrial field buses.

In a first aspect, the present provides a travel drive system, comprising at least one electric motor fed via power electronics which is connected via a DC voltage circuit to a voltage source, and at least one energy storage apparatus for a buffering of energy fed back from the electric motor, wherein said energy storage apparatus includes at least one electrical storage block, a DC/DC converter for the connection of the named DC voltage circuit to an internal voltage circuit of said at least one storage block and a control apparatus for controlling the DC/DC converter, wherein the control apparatus has output and feed control means for controlling the DC/DC converter both for the outputting of current from the storage block to the DC voltage circuit and for the feeding of current from the DC voltage circuit into the storage block, wherein the DC/DC converter is bidirectional, and wherein the storage block, the DC/DC converter and the control apparatus together form a plug-and-play module with outer side power connections for connection of the plug-and-play module to the DC voltage circuit of the power electronics.

In a second aspect, the present invention provides a use of a travel drive system which is configured as defined by the first aspect above, for travelling a lifting gear of a lifting apparatus, wherein electrical energy is buffered in a work cycle of the lifting gear, wherein on a lowering or braking of said lifting gear electrical energy is stored into said at least one electrical storage block of the energy storage apparatus, and is released again from said at least one electrical storage block of the energy storage apparatus on the raising of said lifting gear.

In a third aspect the present invention provides a lifting apparatus, comprising a travel drive system for travelling a lifting gear, said travel drive system having at least one electric motor fed via power electronics which is connected via a DC voltage circuit to a voltage source, and at least one energy storage apparatus for a buffering of energy fed back from the electric motor, wherein said energy storage apparatus includes at least one electrical storage block, a DC/DC converter for the con-nection of the named DC voltage circuit to an internal voltage circuit of said at least one storage block and a control apparatus for controlling the DC/DC converter, wherein the control apparatus has output and feed control means for controlling the DC/DC converter both for the outputting of current from the storage block to the DC voltage circuit and for the feeding of current from the DC voltage circuit into the storage block, wherein the DC/DC converter is bidirectional, and wherein the storage block, the DC/DC converter and the control apparatus are combined to form an energy storage unit having outer side power connections for connection of the energy storage unit to the DC voltage circuit of the power electronics.

Brief Description of the Drawings

The invention will be explained in more detail in the following with respect to preferred embodiments and to associated drawings. There are shown in the drawings:

Fig. 1: a schematic representation of an energy storage apparatus in accordance with a first advantageous embodiment of the invention, wherein two energy storage units, which each comprise a storage block, a control apparatus and a DC/DC converter integrated into a common housing, are arranged connected in parallel with one another and comprise control apparatus communicating with each other and with a higher-ranking control as peers;

Fig. 2: a schematic representation of an energy storage apparatus in accordance with a second advantageous embodiment of the invention in which two energy storage units are likewise arranged connected in parallel with one another, but unlike the embodiment in accordance with Fig. 1, the

control apparatus of the energy storage units act as master and slave units;

Fig. 3: a schematic representation of a drive system with a mains feed and an electric motor controlled via a frequency inverter, wherein the frequency inverter is supplied from a DC voltage intermediate circuit to which the energy storage apparatus from Figures 1 and 2 can be linked; and

Fig. 4: a schematic representation of the link of the storage block of Figures 1 and 2 to the DC voltage intermediate circuit of Fig. 3 via a DC/DC converter.

Detailed Description

Fig. 3 shows an example of a drive system 1 to which the energy storage apparatus in accordance with embodiments of the invention shown by way of example in Figures 1 and 2 can be connected. The drive system 1 can comprise an electric motor M which can be supplied via power electronics 2 from a current source or voltage source 5, wherein the named current source 5 can be a mains connection or also a generator which can, for example be driven by a diesel engine, as is frequently the case with construction machinery. The named electric motor M can drive different adjustment units. They can, for example, as initially stated, be a hoisting gear and/or a travel drive of a lifting apparatus, for example in the form of a crane, in particular of a container bridge crane, or an actuating drive or a drive unit of a mobile construction machine such as a mobile mixer.

As Fig. 3 shows, the power electronics 2 can comprise a frequency inverter 3 which controls and supplies the electric motor M. The named frequency inverter 3 can in turn be supplied from a DC voltage circuit or an intermediate DC voltage circuit 4 which is connected to the current source 5 and which can work as a rectifier. The named intermediate DC voltage circuit 4 can in particular comprise an intermediate circuit capacitor C1 to whose two voltage connections an energy storage apparatus 6 can be connected, as is shown in Figures 1 and 2. The linking of the at least one storage block 7 of the energy storage apparatus 6 can in particular take place via a DC/DC converter 8 which links the output voltage U2 of the storage block 7 to the voltage U1 of the intermediate DC voltage circuit 4, cf. Fig. 4.

When the electric motor M of the drive system 1 drives, energy is taken from the intermediate DC voltage circuit 4 and supplied to the electric motor M, wherein the subsequent supply of the energy from the current source 5 takes place via the mains rectifier which forms the left hand circuit part of the power electronics in Fig. 3. If, however, the electric motor M brakes, energy is fed from the electric motor M into the DC voltage system. In conventional systems without any intermediate energy storage, this fed back energy, designated in Fig. 3 by the reference symbol R1, is typically destroyed to form heat, wherein such high-load resistors can be connected via the DC voltage system by means of electronic switches T5 to avoid any destruction of the power electronics by the fed back energy.

The energy storage system, which is connected, for example, to the connections of the intermediate circuit capacitor C1, now serves not to destroy the fed back energy from the intermediate DC voltage circuit 4, but rather to take it up and to make it available again at a later time. The energy store itself can in this respect be formed from different electric components which can be considered for this purpose. They can in particular be dual-layer capacitors or also battery cells or rechargeable batteries as are used in emergency power plants. For example, a storage block 7, which outputs a variable summed voltage depending on the cell type and the charge state, can be formed from a plurality of such cells - for example a plurality of dual-layer capacitors - by a serial connection and/or a parallel connection.

The circuit is now advantageously configured such that the maximum voltage of the storage block 7 is lower than the minimal voltage of the intermediate DC voltage circuit 4. As Fig. 4 shows, the output voltage U2 of the storage block 7 can be, for example, in the range from 250 to 500 V, whereas the voltage U1 over the connections of the intermediate DC voltage circuit 4 can, for example, amount to 650 V.

The DC/DC converter 8 now connects the two voltage systems to one another, wherein the circuit of the DC/DC converter is able to transfer energy from the high voltage level into the low voltage level, which corresponds to a charging of the storage block 7, and also to transfer it in the other direction, which corresponds to the withdrawal or to an energy transfer from the storage block 7 into the intermediate circuit 4, cf. Fig. 4.

As Figures 1 and 2 show, the energy storage apparatus 6 is advantageously characterized by a plug-and-play configuration so that the energy storage apparatus 6 can be simply connected to the intermediate circuit 4 in the manner of a black box. In this respect, a respective storage block 7, which can, as mentioned, comprise a plurality of storage cells, for example in the form of dual-layer capacitors, is combined together with a DC/DC converter 8 and a control apparatus 9, which effects the energy management of the energy storage apparatus, to form an energy storage unit and is integrated into a common housing 10 which, as mentioned, can be composed of different housing parts. Only two power connections 11 and 12, which can advantageously be configured as plugs, and signal line connections 13 are provided at the outer side of the housing 10 of an energy storage unit, via which signal line connections the control apparatus 9 can communicate with a higher-ranking control PLC or the control apparatus 10 of a different energy storage unit such as via a bus system. Furthermore, respective coolant connections 14 can be provided at the housing 10 of an energy storage unit to be able to connect a cooling circuit integrated into the housing 10 for the cooling of the storage block 7 and/or of the DC/DC converter 8 and/or of the control apparatus 9 to an external cooling circuit of the work machine.

As Fig. 1 shows, a plurality of such energy storage units can be connected in parallel and can be connected in this configuration to the intermediate DC voltage circuit 4, wherein the outwardly leading power connections 11 and 12 can be directly connected in parallel, i.e. + to + and - to -. The mutually connected control apparatus 9 of the energy storage units communicate with one another via the control bus and in particular support the named parallel connection such that all the storage blocks of the units connected in parallel are automatically set to a uniform energy amount.

The storage blocks 7 can in this respect each have a symmetrizing circuit which brings the individual voltages of the storage cells to a value which is as uniform as possible.

As Fig. 2 shows, the control apparatus 9 of the energy storage units connected in parallel can also communicate with one another in a hierarchical manner, wherein a control apparatus 9 acts as a master unit which controls the other control apparatus 9 acting as slave units, supplies them with control defaults and/or with direct control commands and communicates with the higher-ranking system control PLC.

The control apparatus 9 of the storage units can in this respect comprise the control and/or regulation means already initially described in more detail and can be provided with or connected to corresponding sensors, detection circuits or sensor circuits so that the energy storage apparatus 6 or its energy storage units, which can be combined connected in a parallel, can carry out the likewise already initially explained functions.

Other aspects and embodiments of the invention are provided by the following statement numbers 1 to 20.

Statement 1. An energy storage apparatus for connecting to a DC voltage circuit (4) of power electronics (2) of a drive system (1), comprising at least one electrical storage block (7), a DC/DC converter (8) for the connection of the named DC voltage circuit (4) to the internal voltage circuit of the named storage block (7) and a control apparatus (9) for controlling the DC/DC converter (8), characterized in that the DC/DC converter (8) is bidirectional;

the control apparatus (9) has output and feed control means for controlling the DC/DC converter both for the outputting of current from the storage block (7) to the DC voltage circuit (4) and for the feeding of current from the DC voltage circuit (4) into the storage block (7), wherein the storage block (7), the DC/DC converter (8) and the control apparatus (9) are combined to form an energy storage unit having a common housing (10) into which the storage bock (7), the DC/DC converter (8) and the control apparatus (9) are received and to whose outer side two power connections (11, 12) are provided for connection to the DC voltage circuit (4) of the power electronics (2).

Statement 2. An energy storage apparatus in accordance with the preceding statement, wherein the storage block (7) comprises at least one capacitor, preferably a dual-layer capacitor, for energy storage.

Statement 3. An energy storage apparatus in accordance with one of the preceding statements, wherein the at least one storage block (7) and/or the DC/DC convert-er (8) and/or the control apparatus (9) can be linked in the housing (10) to a cooling circuit which has coolant connections (14) at the housing (10) for connection to an external cooling circuit.

Statement 4. An energy storage apparatus in accordance with the preceding statement, wherein the internal and/or external cooling circuit is controllable by the control apparatus (9) in dependence on a temperature of an electric component in the housing (10) and/or on an environmental temperature and/or on an inner housing temperature.

Statement 5. An energy storage apparatus in accordance with one of the two preceding statements, wherein the coolant connections (14) are configured as pluggable.

Statement 6. An energy storage apparatus in accordance with one of the preceding statements, wherein the housing (10) is configured as divisible and comprises a plurality of housing parts which can be put together to form the common housing (10), with different electric components of the energy storage unit, which can be connected to one another by conductive connection means, in particular plug-in contacts, preferably being accommodated in different housing parts.

Statement 7. A energy storage apparatus in accordance with the preceding statement, wherein plug-in contacts, which automatically come into contact on the putting together of the housing parts, are provided at the interfaces of the housing parts.

Statement 8. An energy storage apparatus in accordance with one of the preceding statements, wherein a warning signal device is provided for outputting a warning signal with a storage block (7) still charged with energy and/or a disconnect switch is provided for disconnecting the storage block (7) and/or for deenergizing the power connections (11, 12) at the housing (10).

Statement 9. An energy storage apparatus in accordance with one of the preceding statements, wherein a discharge circuit is provided for converting energy stored in the storage block (7) into heat and is preferably controllable by a control command from outside.

Statement 10. An energy storage apparatus in accordance with one of the preceding statements, wherein the control apparatus (9) comprises control means for determining an energy index and for providing and/or transferring this energy index to a higher-ranking control, with the named energy index representing the energy available in the store.

Statement 11. An energy storage apparatus in accordance with one of the preceding statements, wherein the control apparatus (9) comprises control and/or regulation means for the DC/DC converter which, in response to a control signal from outside, converts definable power values for the charging and/or discharging by desired value defaults for the regulation of the DC/DC converter.

Statement 12. An energy storage apparatus in accordance with one of the preceding statements, wherein the control apparatus (9) comprises power control means for regulating or controlling and/or limiting the maximum transferable powers and/or comprises voltage regulation and/or control means for regulating or controlling the output voltage of the energy storage unit.

Statement 13. An energy storage apparatus in accordance with one of the preceding statements, wherein the control apparatus (9) is configured such that it can be supplied with configurable parameters from the outside and carries out a characteristic-controlled mode of operation on the basis of these configura-ble parameters fed in from the outside.

Statement 14. An energy storage apparatus in accordance with one of the preceding statements, wherein a plurality of energy storage units which each have a storage block (7), a DC/DC converter (8) and a control apparatus (9) accommodated in a housing can be connected to one another in a parallel connection.

Statement 15. An energy storage apparatus in accordance with the preceding statement, wherein the plurality of energy storage units are directly connected to one another by their external power connections (11, 12) in each case plus to plus and minus to minus.

Statement 16. An energy storage apparatus in accordance with one of the two preceding statements, wherein the control apparatus (9) of the energy storage units con-nected in parallel are connected to one another, preferably via a bus system, and support the parallel connection such that all the storage blocks (7) are set and/or controlled to an at least approximately uniform energy amount.

Statement 17. An energy storage apparatus in accordance with one of the preceding statements, wherein the control apparatus (9) of an energy storage unit is defined as a master unit and the control apparatus (9) of the other energy storage units are defined as slave units which are controllable by the named master unit.

Statement 18. A drive system having at least one electric motor (M) which can be fed via power electronics (2) which can be connected via a DC voltage circuit (4) to a voltage source (5) and furthermore having at least one energy storage ap-paratus (6) for a buffering of energy fed back from the electric motor (M), wherein the ener-

2018201751 12 Mar 2018

gy storage apparatus is configured in accordance with one of the preceding statements and is connectable to the DC voltage circuit (4).

Statement 19. A drive system in accordance with the preceding statement, wherein the maxi-mum voltage (U2) of the at least one storage block (7) of the energy storage apparatus (6) is kept lower than the minimal voltage of the DC voltage circuit (4).

Statement 20. A drive system in accordance with one of the two preceding statements, wherein both the feeding of fed back energy of the electric motor (M) into the energy storage apparatus (6) and the outputting of buffered energy from the energy storage apparatus (6) to the DC voltage circuit (4) takes place via the DC/DC converter (8) of the energy storage apparatus (6).

Statement 21. A lifting apparatus, in particular a crane such as a container bridge crane, comprising a drive system in accordance with one of the preceding statements.

Statement 22. A construction machine, in particular a concrete mixer vehicle, comprising a drive system in accordance with one of the preceding statements.

Claims

1. A travel drive system, comprising at least one electric motor fed via power electronics which is connected via a DC voltage circuit to a voltage source, and at least one energy storage apparatus for a buffering of energy fed back from the electric motor, wherein said energy storage apparatus includes at least one electrical storage block, a DC/DC converter for the connection of the named DC voltage circuit to an internal voltage circuit of said at least one storage block and a control apparatus for controlling the DC/DC converter, wherein the control apparatus has output and feed control means for controlling the DC/DC converter both for the outputting of current from the storage block to the DC voltage circuit and for the feeding of current from the DC voltage circuit into the storage block, wherein the DC/DC converter is bidirectional, and wherein the storage block, the DC/DC converter and the control apparatus together form a plug-and-play module with outer side power connections for connection of the plug-and-play module to the DC voltage circuit of the power electronics.

2. The travel drive system as defined in claim 1, wherein the storage block, the DC/DC converter and the control apparatus are accomodated in a common housing to whose outer side said two power connections are provided for connection to the DC voltage circuit of the power electronics.

3. The travel drive system in accordance with claim 1 or 2, wherein the maximum voltage of the at least one storage block of the energy storage apparatus is kept lower than the minimal voltage of the DC voltage circuit.

4. The travel drive system in accordance with one of the two preceding claims, wherein both the feeding of fed back energy of the electric motor into the energy storage apparatus and the outputting of buffered energy from the energy storage apparatus to the DC voltage circuit takes place via the DC/DC converter of the energy storage apparatus.

5. Use of a travel drive system which is configured as defined by any one of claims 1 to 4, for travelling a lifting gear of a lifting apparatus, wherein electrical energy is buffered in a work cycle of the lifting gear, wherein on a lowering or braking of said lifting gear electrical energy is stored into said at least one electrical storage block of the energy storage apparatus, and is released again from said at least one electrical storage block of the energy storage apparatus on the raising of said lifting gear.

6. The use of the travel drive system as defined by claim 5, wherein, when the electric motor brakes, energy is fed from the electric motor into the DC voltage circuit and stored into a plurality of dual-layer capacitors of said at least one storage block, and wherein, when said electric motor drives to raise said lifting gear, electrical energy is fed back from said plurality of dual-layer capacitors of said at least one storage block to said motor.

7. A lifting apparatus, comprising a travel drive system for travelling a lifting gear, said travel drive system having at least one electric motor fed via power electronics which is connected via a DC voltage circuit to a voltage source, and at least one energy storage apparatus for a buffering of energy fed back from the electric motor, wherein said energy storage apparatus includes at least one electrical storage block, a DC/DC converter for the connection of the named DC voltage circuit to an internal voltage circuit of said at least one storage block and a control apparatus for controlling the DC/DC converter, wherein the control apparatus has output and feed control means for controlling the DC/DC converter both for the outputting of current from the storage block to the DC voltage circuit and for the feeding of current from the DC voltage circuit into the storage block, wherein the DC/DC converter is bidirectional, and wherein the storage block, the DC/DC converter and the control apparatus are combined to form an energy storage unit having outer side power connections for connection of the energy storage unit to the DC voltage circuit of the power electronics.

2018201751 12 Mar 2018

8. The lifting apparatus as defined in the preceeding claim, wherein said voltage source is a grid feeding said power electronics via said DC voltage circuit.

9. The lifting apparatus as defined in claim 7, wherein said voltage source is a generator driven by a combustion engine and feeding said power electronics via said DC voltage circuit.

10. The lifting apparatus as defined in any one of claims 7 to 9, wherein the storage block, the DC/DC converter and the control apparatus together form a plug-and-play module having a common housing in which said storage block, the DC/DC converter and the control apparatus are received, said common housing having at its outer side power connections configured to be releasably connected to the DC voltage circuit of the power electronics.

11. The lifting apparatus in accordance with claim 10, wherein the storage block comprises at least one capacitor, preferably a dual-layer capacitor, for energy storage.

12. The lifting apparatus in accordance with any one of claims 7 to 11, wherein the at least one storage block and/or the DC/DC converter and/or the control apparatus can be linked in the housing to a cooling circuit which has coolant connections at the housing for connection to an external cooling circuit.

13. The lifting apparatus in accordance with claim 12, wherein the internal and/or external cooling circuit is controllable by the control apparatus in dependence on a temperature of an electric component in the housing and/or on an environmental temperature and/or on an inner housing temperature.

14. The lifting apparatus in accordance with claim 12 or 13, wherein the coolant connections are configured as pluggable.

15. The lifting apparatus in accordance with any one of claims 7 to 14, wherein the housing is configured as divisible and comprises a plurality of housing parts which can be put together to form the common housing, with different electric components of the energy storage unit, which can be connected to one another by conductive connection means, in particular plug-in contacts, preferably being accommodated in different housing parts.

16. The lifting apparatus in accordance with claim 15, wherein plug-in contacts, which automatically come into contact on the putting together of the housing parts, are provided at the interfaces of the housing parts.

17. The lifting apparatus in accordance with any one of claims 7 to 16, wherein a warning signal device is provided for outputting a warning signal with a storage block still charged with energy and/or a disconnect switch is provided for disconnecting the storage block and/or for deenergizing the power connections at the housing.

18. The lifting apparatus in accordance with any one of claims 7 to 17, wherein a discharge circuit is provided for converting energy stored in the storage block into heat and is preferably controllable by a control command from outside.

19. The lifting apparatus in accordance with any one of claims 7 to 18, wherein the control apparatus comprises control means for determining an energy index and for providing and/or transferring this energy index to a higher-ranking control, with the named energy index representing the energy available in the store.

20. The lifting apparatus in accordance with any one of claims 7 to 19, wherein the control apparatus comprises control and/or regulation means for the DC/DC converter which, in response to a control signal from outside, converts definable power values for the charging and/or discharging by desired value defaults for the regulation of the DC/DC converter.

21. The lifting apparatus in accordance with any one of claims 7 to 20, wherein the control apparatus comprises power control means for regulating or controlling and/or limiting the maximum transferable powers and/or comprises voltage regulation and/or control means for regulating or controlling the output voltage of the energy storage unit.

22. The lifting apparatus in accordance with any one of claims 7 to 21, wherein the control apparatus is configured such that it can be supplied with configurable parameters from the outside and carries out a characteristic-controlled mode of operation on the basis of these configurable parameters fed in from the outside.

23. The lifting apparatus in accordance with any one of claims 7 to 22, wherein a plurality of energy storage units which each have a storage block, a DC/DC converter and a control apparatus accommodated in a housing, are connected to one another in a parallel connection.

24. The lifting apparatus in accordance with claim 23, wherein the plurality of energy storage units are directly connected to one another by their external power connections in each case plus to plus and minus to minus.

25. The lifting apparatus in accordance with claim 23 or 24, wherein the control apparatus of the energy storage units are connected to one another via a bus system, and are configured to automatically adjust all the storage blocks to an at least approximately uniform energy amount.

26. The lifting apparatus in accordance with any one of claims 23 to 25, wherein the control apparatus of one energy storage unit is defined as a master unit and the control apparatus of the other energy storage units are defined as slave units which are controllable by said master unit.

2018201751 12 Mar 2018

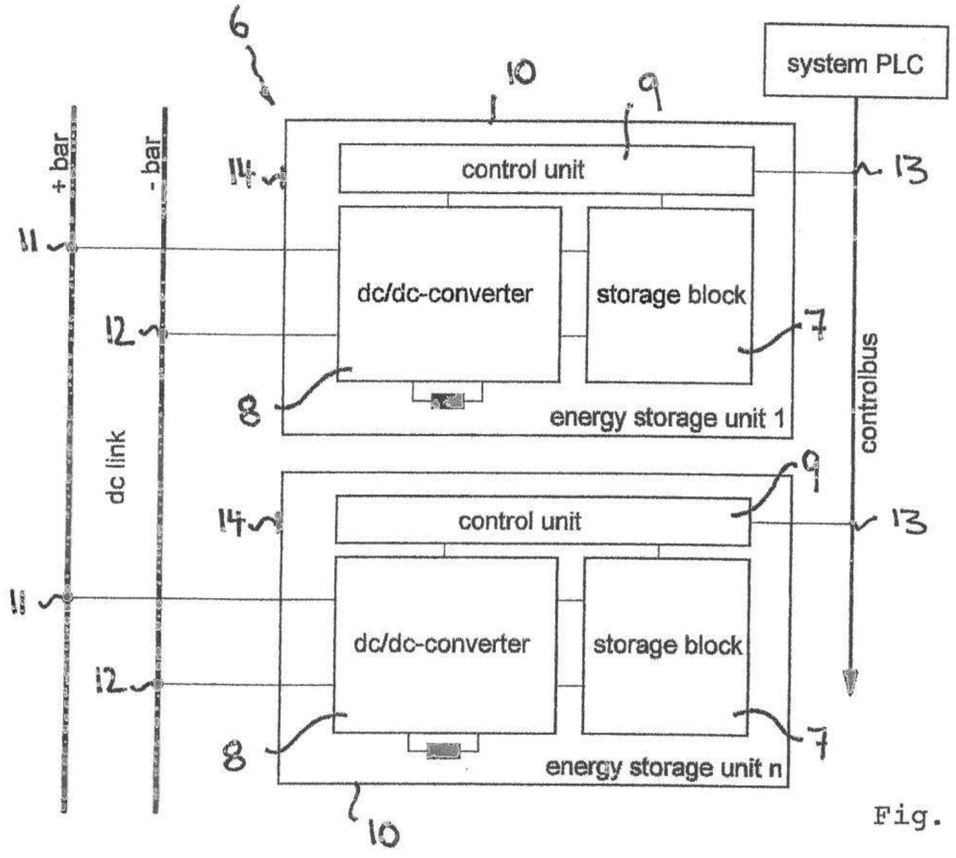

Fig. 1

2018201751 12 Mar 2018

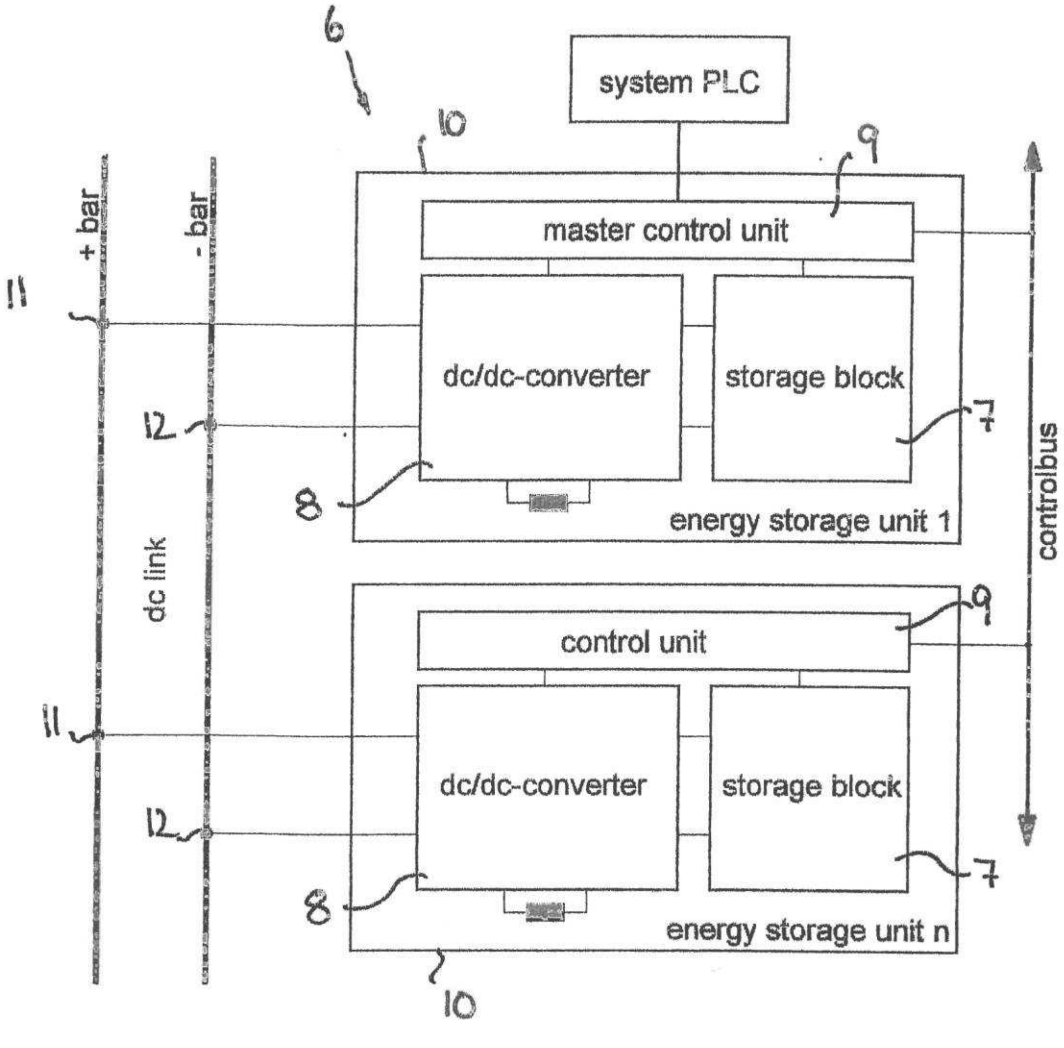

Fig. 2

2018201751 12 Mar 2018

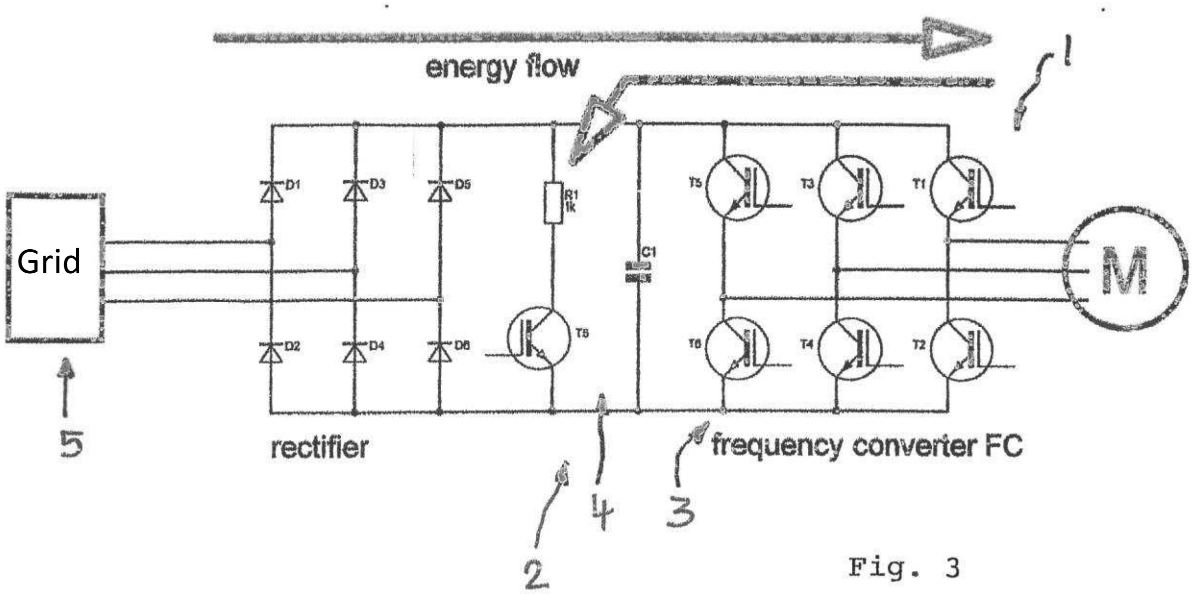

Fig. 3

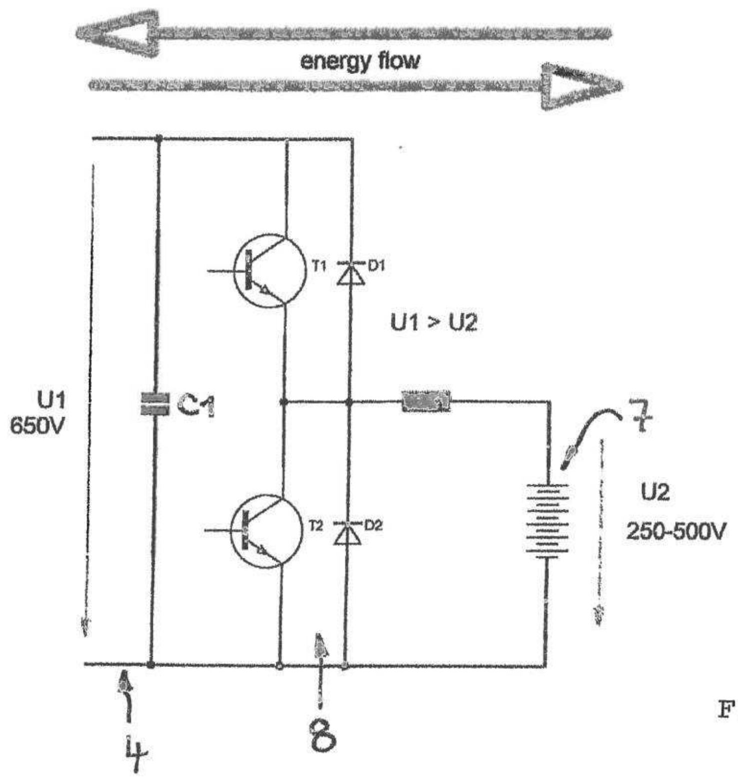

Fig. 4