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Background of the invention

The invention relates to a power supply device for supplying a plurality of loads with direct current.

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The invention furthermore relates to a method for operating a power supply device.

A power supply device of this kind is known for example from DE 10 2010 030 821 A1.

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Loads from signaling equipment in rail technology are generally supplied with power via a central point (interlocking). The energy supply of the field elements is achieved by turning on the systems in the interlocking.

15 DE 10 2013 225 815 A1 discloses a power supply device by means of which the power is supplied via a bus line of an energy bus.

The energy distribution is thus shifted along the energy bus. In this way, cost-effective power distribution can be achieved over large distances (here: distances of 20-50 km), since bus systems can deal with statistically distributed power fluctuations over the distance in a more material-efficient manner when metal conductors (in particular copper or aluminum) are used. However, faults in power distribution can no longer be managed in the interlocking, but are instead managed by active elements of the energy bus system.

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The overall availability is a challenge, because a plurality of loads (field elements) are connected to one bus line. Owing to the plurality of loads, an extremely high switch-on current results upon turning on (starting up the distributed power supplies of the loads (field elements)).

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Due to material-efficient use of metal conductors the bus line has a higher resistance compared with conventional energy distribution systems, with the result that power fluctuations cause larger voltage fluctuations.

35 US 5,962,929 discloses a power supply system, in which the loads to be supplied are connected to the power supply in series. By means of a switch. In the event of a

short circuit within one load, said load is bypassed, with the result that all loads are always supplied with power.

DE 10 2010 030 821 A1 discloses a device for starting up field devices connected in parallel, which devices are operated by means of one single supply source. The device comprises a starting circuit which is used to isolate a field device following a preceding field device from the voltage source at least until the preceding field device consumes a substantially constant power that is used for operating the preceding field device in a specified operating mode.

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Problem addressed by the invention

The problem addressed by the invention is that of proposing a power supply device in which the loads can be reliably supplied with power via a bus line, in particular also in the event of a fault, and at the same time the switch-on current, and thus the voltage drop, can be kept under control, even in the case of a plurality of loads.

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Description of the invention

20 This problem is solved according to the invention by a power supply device according to claim 1 and by a method according to claim 11. The dependent claims relate to advantageous embodiments.

An "energy bus" refers to a successive arrangement of a plurality of loads along a (2-pole) bus line having a common power supply. According to the present invention, in addition to the bus line, the energy bus also comprises load-bus coupling elements which are arranged along the bus line, i.e. in succession, and which subdivide the bus line into bus segments, as well as infeed bus coupling elements, depending on the number of power supply (DC power sources), through which power coming from the DC power source(s) can be fed into the bus line. The energy bus can have a linear (open bus line) or an annular (closed bus line) topology. The flow electricity within the energy bus is bidirectional.

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The bus line is subdivided into bus segments by load-bus coupling elements, each load-bus coupling element comprising switching elements for electrically disconnecting the bus line, such that each bus coupling element can be brought into

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a basic state and/or into a first operating state in which the bus line is electrically disconnected by the corresponding load-bus coupling element, and can be brought into a second operating state in which the bus segments are electrically connected by the corresponding load-bus coupling element, and such that at least one of the loads is connected to one of the load-bus coupling elements and thus supplies said load. As many load-bus coupling elements as desired can be arranged within one bus line.

A load is connected to at least one load-bus coupling element such that said load is supplied by the load-bus coupling element, the load-bus coupling elements generally being functionally independent of the respective loads. It is also possible, however, to provide bus coupling elements that do not supply any loads.

The load-bus coupling elements form disconnection points at which the bus line can be interrupted. The isolation/interruption of the bus line refers to the lack of an electrically conductive connection between adjacent bus segments. As a result, electrical isolation is achieved in the voltage potential range of the operating voltage.

The inventive division, of the bus line into a plurality of bus line portions (bus segments) by means of the load-bus coupling elements (electrical interruption of the bus line at disconnection points) makes it possible to turn on the loads sequentially, and thus to reduce the current peaks that occur when turning on the loads.

Electromechanical relays or electronic switching elements such as thyristors, transistors and FETs, for example, can be used as switching elements.

The load-bus coupling elements preferably each comprise the above-mentioned switching elements, a microprocessor for operating said switching elements, electronics for line transmission diagnostics, and filters and protective devices. At the interface to the load, the microprocessor performs the processes of turning on and monitoring the wide-range power supply of the load as the actual net load.

According to the invention, the loads are components of control and safety technology, in particular field elements, the loads in each case comprising logics or a processor.

The power supply device according to the invention is thus preferably used in rail technology, in particular in control and safety technology.

Field elements are elements that are arranged along a rail traffic route, in particular switches, signals, etc. The field elements preferably each comprise a wide-range power supply (in particular 450 VDC - 900 VDC; approx. 500 W - 1 kW), various electronics comprising processors, and a connection to the data communications network.

10 In a first preferred embodiment, the energy bus has a linear topology and the first DC power source is the only DC power source of the first energy bus. In this case, for example, only the first load-bus coupling element can be connected directly (i.e. without interconnection of a further load-bus coupling element equipped with a load) to the first DC power source. The further load-bus coupling elements then in each case adjoin the preceding load-bus coupling element (feed point at one of the two ends of the energy bus). In this case, the infeed of power takes place at just one single point. In the case of a fault, the entire bus or parts of the bus drops out. It is also possible, however, to arrange the first DC power source at any desired point of the energy bus, e.g. between two load-bus coupling elements. The infeed of power from the single DC power source into the bus line then takes place in two directions.

According to a second embodiment of a power supply device according to the invention, the first and the nth load-bus coupling elements are directly connected to the first DC power source, such that the energy bus has an annular topology. This embodiment allows for infeed of power from both sides, by means of just one DC power source. As a result, all the loads can be supplied with power, in spite of a fault occurring in one segment of the bus line (first level fault correction).

The bus line is preferably electrically connected to a further (i.e. a second or possibly also third, fourth, etc.) DC power source (third and fifth embodiment).

In the third advantageous embodiment, one of the load-bus coupling elements, preferably the nth load-bus coupling element, is directly connected to the further (in particular the second) DC power source. In this embodiment, the energy bus has a linear topology having infeed of power from both sides, by means of two DC power sources.

For the purpose of increased availability, it is advantageous for more than one further DC power source (i.e. more than two DC power sources in total) to be electrically connected to the bus line (third and fifth embodiment).

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From these variants, first and, in some cases second, level fault correction can be achieved.

10 According to the invention, a bus coupling unit is provided which couples the first energy bus to a second energy bus. A bus coupling unit comprises at least four connections (coupling of two energy buses) and can occupy any electrically permissible positions (i.e. in particular short circuit-free paired couplings of two-pole bus lines), including multiple positions.

15 Said coupling unit can also couple together more than two energy buses. Furthermore, a power supply device can also comprise a plurality of coupling units which each coupling at least two energy buses.

20 In the case of an annular topology of the energy bus(es), the bus coupling unit divides the annular bus line(s) of adjacent energy buses into a first line portion and a second line portion in each case. In the event of a fault occurring in both the first line portion and the second line portion of an energy bus, the loads that can no longer be supplied by the DC power source of the specific bus can be supplied by the DC power source of the second bus (second level fault correction). For this purpose, the
25 bus coupling unit comprises for example further switching elements for electrically connecting the line portion of the first energy bus that can no longer be supplied to the second energy bus.

30 In this case, according to a fourth embodiment, the first and the second energy bus (preferably all energy buses of the power supply device) have an annular topology. This embodiment is advantageous in particular if large distances have to be covered at a high level of availability, for example in order to connect two rail networks.

35 According to a fifth and sixth embodiment, the first and the second energy bus (preferably all energy buses of the power supply device) have a linear topology. This embodiment can advantageously be used for connecting large track areas.

In a seventh embodiment, an energy bus having an annular topology and an energy bus having a linear topology are coupled to one another by the bus coupling unit.

- 5 The load-bus coupling element preferably has, on the negative and on the positive potential side of the bus line, in each case a first switching element for electrically disconnecting the bus line and a second switching element for connecting the load to the energy bus, the first switching elements being part of the bus line and the second switching elements being part of a supply line which is integrated in the
10 load-bus coupling element and leads from the bus line to the load.

- The invention also relates to a method for operating a power supply device described above, in particular in rail technology. According to the invention, the load-bus coupling elements are brought from the basic state into the second operating
15 state sequentially such that the load-bus coupling elements are turned on sequentially by supplying power from the DC power source.

- The power from the DC power source is preferably fed into the bus line on both sides.
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- In this case, at least one additional DC power source can be used for feeding in on both sides. This allows for a linear topology of the energy bus to be used. Preferably, more than two DC power sources are used. It is thus possible for balancing of the energy supply to be performed in the resistively loaded bus, by
25 means of controlling the voltage of the DC power sources.

Alternatively thereto, an energy bus which has an annular topology and a single DC power source may be used for feeding in on both sides.

- 30 The DC power sources input power into the energy bus by means of one infeed-bus coupling element in each case. As many DC power sources as desired can be provided within one energy bus. The number of infeed-bus coupling elements is determined by the number of DC power sources.

- 35 The infeed-bus coupling elements preferably comprise a series of switching elements and diodes. The switching elements isolate the bus at the segment

boundaries and allow for controlled, independent infeed of the power into the adjacent bus lines. The diodes or controlled switches decouple the power supply (DC power sources) in the case of reverse energy input (e.g. by using additional DC power sources in the case of short lines and different voltages).

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All the power supply devices described can be designed as IT (isolé terre) power supply networks. This network standard is preferably used in rail technology, in particular in control and safety technology.

- 10 In the event of a defective segment of the bus line (e.g. in the case of an interruption or short circuit), the load-bus coupling elements which adjoin the defective segment are preferably put into the first operating state. The bus line is thus then interrupted at the defective point. Owing to the infeed from both sides, however, all loads can nonetheless be supplied with power. In the event of a short circuit in one bus
- 15 segment, the relevant bus segment is thus isolated by the adjacent load-bus coupling elements.

Further advantages of the invention can be found in the description and the drawings. Likewise, according to the invention, the features mentioned above and

20 those set out in the following can each be used individually or together, in any desired combinations. The embodiments shown and described are not to be considered a conclusive list, but instead are provided by way of example, in order to illustrate the invention.

25 Detailed description of the invention and drawings

Fig. 1 shows an energy bus according to the prior art.

Fig. 2a shows a power supply device by way of example, comprising a first DC power source that feeds in on one side, and an energy bus having linear topology.

- 30 Fig. 2b shows an example comprising a first DC power source that feeds in on two sides, at any desired point, and an energy bus having linear topology.

Fig. 3a shows a preferred structure of a load-bus coupling element in the basic state.

- Fig. 3b shows a preferred structure of a load-bus coupling element in the first
- 35 operating state.

Fig. 3c shows a preferred structure of a load-bus coupling element in the second

operating state.

Fig. 4 shows a preferred structure of an infeed-bus coupling element.

Fig. 5 shows a power supply device by way of example, comprising a first DC power source and an energy bus having annular topology.

5 Fig. 6a shows a power supply device by way of example, comprising a plurality of DC power sources and an energy bus having linear topology.

Fig. 6b shows the power supply device comprising two DC power sources, in which all load-bus coupling elements are in the second operating state.

Fig. 6c shows the power supply device comprising two DC power sources, in which
10 one bus segment is isolated owing to a short circuit.

Fig. 7a is a detail of an embodiment of the power supply device according to the invention, comprising two coupled energy buses having annular topology.

Fig. 7b shows the power supply device according to the invention according to Fig. 7a comprising an interrupted segment in the main line portion.

15 Fig. 7c shows the power supply device according to the invention according to Fig. 7a comprising an interrupted segment in the main line portion and an additional interruption in the return line portion.

Fig. 8 shows an embodiment of the power supply device according to the invention, comprising two coupled energy buses having linear topology, and a plurality
20 of DC power sources.

Fig. 9 shows an embodiment of the power supply device according to the invention, comprising a plurality of energy buses connected in a star-like manner and having linear topology, and one central network coupling unit.

Fig. 10 shows an embodiment of the power supply device according to the
25 invention, in which one energy bus having linear topology is coupled to one energy bus having annular topology.

Fig. 1 shows an energy bus according to the prior art comprising two DC power sources **PS1**, **PS2** which are electrically connected to a plurality of loads (field
30 elements **FE**) via a bus line **L**. For this purpose, the bus line **L** comprises branch lines **A** which lead to the field elements **FE**. If a fault, e.g. a short circuit, occurs in an arrangement of this kind, this affects the entire energy bus, with the result that none of the field elements **FE** can be operated any longer. In addition, owing to the large number of field elements **FE** a higher switch-on current occurs.

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Fig. 2a, 2b show two variants of a first embodiment of the power supply device

according to the invention **SV1**, **SV1'**, each comprising an energy bus having a linear topology. The energy bus comprises a bus line L3, a first unidirectional feeding DC power source PS1 and an infeed-bus coupling element SBA1 by means of which power is fed into the bus line L3. Disconnection points **U1 ... Un**, **US1 ...**
 5 **USm** (here: $m=1$) are provided in the bus line L3, at which disconnection points n load-bus coupling elements **VBA1 ... VBAn** and the infeed-bus coupling element SBA1 subdivide the bus line L3 into bus segments **BS**. The number s of the bus segments is dependent on the number n of the load-bus coupling elements and the number m of the infeed-bus coupling elements. In the case of an energy bus having
 10 linear topology, the number s of the bus segments is $s = m+n+1$. The loads **FE1 ... FEn** are in each case connected downstream of one load-bus coupling element VBA1 ... VBAn, respectively. Electrical isolation can be achieved at the corresponding disconnection points (basic state or first operating state - see Fig. 3a, 3b; or isolation of the power supply- see Fig. 4) by means of the load- and the
 15 infeed-bus coupling elements VBA1 ... VBAn (at disconnection points **U1 ... Un**), and the infeed-bus coupling elements SBA1 ... SBAm (at disconnection points **US1 ... USm**). In the examples shown, no load is connected downstream of the fourth load-bus coupling element VBA4. Load-bus coupling elements VBA4 without downstream loads FE can be used as a reserve for loads that are to be connected in future.

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In Fig. 2a, the first DC power source PS1 is directly connected only to the first load-bus coupling element VBA1, and thus forms the boundary of the energy bus (one-sided infeed).

25 In Fig. 2b, the first DC power source PS1 is arranged between two load-bus coupling elements VBA2, VBA3. The energy bus thus has a two-part linear topology. In this case, the infeed-bus coupling element SBA1 can operate the energy bus on both sides. This property is also made use of in the annular topologies described later.

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A preferred structure of a load-bus coupling element VBA installed in a bus line L is shown in **Fig. 3a**, **3b** and **3c**. The load-bus coupling element VBA comprises switching elements **S1**, **S2**, diodes **D** and a microprocessor **KP**. The diodes are used for connecting the microprocessor KP and the loads FE to the bus line L. The
 35 switching elements S1 interrupt the bus line L, in other words segment it into bus segments. The switching element S2 are used for connecting the load. The

switching elements S1, S2 are preferably designed as a relay or electronic switching element.

The load-bus coupling element VBA has the following operating states: In the basic state shown in Fig. 3a, the microprocessor KP is fed on one or both sides by the bus line L, via the diodes. All the switching elements S1 and S2 are open. In the first operating state shown in Fig. 3b, the load FE is connected by means of the second switching element S2. After a time delay, the bus line is through-connected by the first switching elements S1, as shown in Fig. 3c (second operating state).

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The power supply device as shown for example in Fig. 2a is operated according to the invention such that initially all the load-bus coupling elements VBA1 ... VBAn are in the basic state, such that the bus line L3 is interrupted by each of the load-bus coupling elements VBA1 ... VBAn. Thus, switching on the power of the DC power source PS1 initially supplies power only to the load-bus coupling element closest to the DC power source PS1 (first load-bus coupling element VBA1), such that the first load-bus coupling element VBA1 itself and the load FE1 downstream of the first load-bus coupling element VBA1 can be turned on. In this case, the functionality of the load-bus coupling element VBA1 can turn itself on when the power supply SP1 is present. During said switch-on process, the load power supply is connected by closing the second switching elements S2. The load-bus coupling element VBA1 is then in the first operating state. If said voltages are applied in a stable manner, the electronics of the load FE1 switches on. Once the load FE1 of the first load-bus coupling element VBA1 is ready for operation (turned on/started up), the first load-bus coupling element VBA1 is brought into the second operating state, i.e. the bus is through-connected up to the next (second) load-bus coupling element VBA2 by means of the switching element S1, as a result of which the next load-bus coupling element (second load-bus coupling element VBA2) is supplied with power, etc. the loads FE1 ... FEn are thus turned on in succession, such that only the low switch-on current of a single load FE1 ... FEn arises even when using a plurality of loads FE1 ... FEn.

Fig. 4 shows the basic form of the structure of an infeed-bus coupling element **SBA**, a DC power source **PS** being connected to the bus line L by means of the infeed-bus coupling element SBA. In this case, the infeed coupling is achieved by means of diodes **D1**. Said diodes decouple the power supply PS in the case of reverse energy

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input (e.g. by a second power supply (see e.g. Fig. 6a) in the case of short lines and different voltages). The diodes D1 can also be implemented as controlled switches. The diodes D2 are used for decoupling the power supply of the microprocessor KP. Switching elements **S3** and **S4** are used for isolating the potential-free power supply PS from the bus line L. Temporally separating the switch-on, by means of the switching elements S3 and S4, also allows for two-part linear energy buses to be started up sequentially, as shown in Fig. 2b.

Fig. 5 shows a second variant of the power supply device **SV2**. In contrast to the power supply device SV1 shown in Fig. 2, the energy bus of the power supply device SV2 according to Fig. 5 has an annular topology. For this purpose, the DC power source PS1 is connected by the infeed-bus coupling element SBA1 to both the first load-bus coupling element VBA1 and the nth load-bus coupling element VBAn, such that power infeed can take place bidirectionally. The bus line L1 is subdivided into n+m bus segments BS by means of the bus coupling elements SBA1, VBA1 ... VBAn.

A further possibility of how power infeed on both sides can be achieved is shown in **Fig. 6a-c**. The third embodiments of the power supply device **SV3**, **SV3'** according to the invention shown therein comprise an energy bus having a linear topology. Fig. 6a shows an embodiment SV3 comprising three DC power sources PS1, **PS2**, **PS3**. Fig. 6b, c show an embodiment SV3' comprising two DC power sources PS1, PS2. In both cases, each load-bus coupling element VBA1 ... VBAn can be fed from both sides. The sequential start-up then preferably takes place, proceeding from the two DC power sources PS1, PS2, at the same time from both sides of the energy bus. For this purpose, the first load-bus coupling element VBA1 is connected to the first DC power source PS1 via the infeed-bus coupling element SBA1, and the nth load-bus coupling element VBAn can be connected to the additional DC power sources PS2 via an additional infeed-bus coupling element SBA2. In the case of a fault (short circuit KS) in the bus segment BS' (Fig. 6c), the relevant bus segment BS' can be isolated by means of the adjacent load-bus coupling elements (here: load-bus coupling elements VBA2, VBA3) being brought into the first operating state by opening the switching elements S1, as shown in **Fig. 6c**. The loads FE1, FE2 can then be supplied via the first DC power source PS1, and the loads FE3 ... FEn via the additional DC power source PS2 (first level fault correction).

Fig. 7a-c shows an embodiment of the power supply device **SV4** according to the invention in which a first energy bus **B2** having a bus line **L1** is electrically coupled to a second energy bus **B2'** having a bus line **L2**, by means of a bus coupling unit **K**. In this case, the bus lines **L1**, **L2** are each subdivided, by means of the bus coupling unit **K**, into a main line portion **L1a**, **L2a**, in which at least two load-bus coupling elements **VBA1**, ..., **VBA5** are arranged, and a return line portion **L1b**, **L2b**, in which load-bus coupling elements are not necessarily arranged. Loads **FE1**, ..., **FE5** are connected to the load-bus coupling elements **VBA1**, ..., **VBA5**. Both energy buses **B2**, **B2'** have an annular topology according to Fig. 5. Fig. 7b shows the case in which one segment of the main line portion **L1a** has been isolated owing to a fault arising (first level fault correction). Owing to the coupling by means of the bus coupling unit **K**, the load-bus coupling elements **VBA1**, ..., **VBA5** and the loads **FE1**, ..., **FE5** connected thereto in the main line portion **L1a** continue to be operated, even in the case of a fault additionally arising in the return line portion **L1b**, as shown in Fig. 7c. For this purpose, the load-bus coupling elements **VBA4**, **VBA5** of the first energy bus **B2** which cannot be supplied by the first DC power source **PS1** owing to the fault in the main line portion **L1a** and return line portion **L1b** are electrically connected to the second energy bus **B2'** by means of the bus coupling unit **K** (second level fault correction).

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Fig. 8 shows an embodiment of the power supply device **SV5** according to the invention power, in which two energy buses **B1**, **B1'** having linear topology and two DC power sources **PS1**, **PS2**, **PS1'**, **PS2'**, respectively, are electrically coupled by means of the bus coupling unit **K**.

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Five load-bus coupling element **VBA1** ... **VBA5** are connected to the first energy bus **B1**, the first DC power source **PS1** being directly electrically connected only to the first load-bus coupling element **VBA1** and thus feeding in power in just one direction. The additional DC power source **PS2** is arranged between the third load-bus coupling element **VBA3** and the fourth load-bus coupling element **VBA4** (i.e. directly electrically connected both to the third load-bus coupling element **VBA3** and to the fourth load-bus coupling element **VBA4**), such that infeed takes place in two direction. The second energy bus **B1'** comprises two DC power sources **PS1'**, **PS2'** and three load-bus coupling elements **VBA1'** ... **VBA3'**, to which one load **FE1'** ... **FE3'** is connected in each case. In this embodiment, too, the coupling by means of the bus coupling unit **K** allows for the load-bus coupling elements **VBA1** ... **VBA5**,

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VBA1' ... VBA3' and the loads connected thereto to continue to be operated, even in the case of a fault arising. In particular, the load-bus coupling elements VBA4, VBA5, VBA1' can be supplied with power from the power source PS2, PS2' of the other energy bus B1, B1' in each case (first level fault correction).

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This embodiment of the power supply device also overcomes further additional faults (higher level fault correction). Failure of the DC power source PS2 in the first energy bus B1 will be described by way of example. In the case of a voltage loss, diodes in the infeed-bus coupling element SBA2 (corresponding to the diodes D1 in the infeed-bus coupling element SBA in Fig. 4) isolate the voltage source PS2 from the bus line. The switching elements S3 and S4 remain closed, controlled by the microprocessor KP (see Fig. 4). Thus, even if the coupler K of the infeed-bus coupling element SBA2 is open, the load-bus coupling elements VBA4 and VBA5 are still supplied by the first DC power source PS1.

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Fig. 9 shows an embodiment of the power supply device **SV6** according to the invention, in which, by way of example, four energy buses having linear topology and one DC power source PS1, PS1', **PS1''**, **PS1'''**, respectively, are electrically connected, in a starlike manner, by means of the coupling unit K. A "starlike" coupling of this kind is generally possible using n energy buses, where $n > 2$, it wherein a power supply device coupled in a starlike manner may comprise energy buses having both linear and annular topology. The coupling unit K must comprise a sufficient number of ports, according to the number and topology of the energy buses that are to be coupled.

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Fig. 10 shows an embodiment of the power supply device **SV7** according to the invention, in which one energy bus B1 having linear topology (similar to Fig. 2) is coupled to one energy bus B2 having annular topology (similar to Fig. 5) by means of the bus coupling unit K. Both energy buses B1, B2 comprise one DC power source PS1, PS1', respectively. Five load-bus coupling elements VBA1, ..., VBA5 are connected to the bus line L3 of the first energy bus B1. Four load-bus coupling elements VBA1', ..., VBA4' are arranged in the second energy bus B2, the load-bus coupling element VBA4' being located not in the main line portion L2a but instead in the return line portion L2b of the bus line L2. This embodiment allows for first and second level fault correction. The bus coupling unit K can assume all possible combined positions (between the connections used).

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All the embodiments comprise a segmented energy bus, the segmentation being achieved by load-bus coupling elements and infeed-bus coupling elements which can be brought from a basic state, in which the segments of the bus line adjacent to the relevant bus coupling element are electrically isolated from one another, into a second operating state, in which said segments are electrically interconnected. The switchable segmentation is an essential performance feature for localizing line faults (diagnosis function).

10 List of reference signs

	A:	branch lines
	B1, B1':	energy bus having linear topology
15	B2, B2':	energy bus having annular topology
	BS:	bus segment, segments of the bus line
	D, D1, D2:	diodes
	FE:	load (field element)
	FE, FE1 ..FEn:	loads of a first energy bus
20	FE1' ..FE3':	loads of a second energy bus
	K:	bus coupling unit
	KP:	microprocessor
	KS:	short circuit
	L:	bus line (2-pole)
25	L1, L2:	bus lines of an energy bus having annular topology
	L3:	bus lines of energy bus having linear topology
	L1a, L2a:	main line portions of the bus lines (annular topology)
	L1b, L2b:	return line portions of the bus lines (annular topology)
	PS, PS1, PS2, PS3:	power supplies (DC power sources) of a first energy bus
30	PS1', PS2':	power supplies (DC power sources) of a second energy bus
	PS1'':	power supplies (DC power sources) of a third energy bus
	PS1'':	power supplies (DC power sources) of a fourth energy bus
	SV1:	power supply device comprising a DC power source and having linear bus topology
35	SV2:	power supply device comprising a DC power source and having annular bus topology

- SV3, SV3': power supply device comprising a plurality of DC power sources and having linear bus topology
- SV4, SV5, SV6, SV7: power supply devices comprising coupled energy buses
- S1, S2: switching elements of the load-bus coupling elements
- 5 S3, S4: switching elements of the infeed-bus coupling elements-bus coupling elements
- SBA, SBA': infeed-bus coupling elements
- SBA1, SBA2: infeed-bus coupling elements of the first energy bus
- SBA1', SBA2': infeed-bus coupling elements of the second energy bus
- 10 SBA1'', SBA2'': infeed-bus coupling elements of the third energy bus of the starlike power supply device
- SBA1''', SBA2''': infeed-bus coupling elements of the fourth energy bus of the star shaped power supply device
- U, U1 ... Un: disconnection points of the load-bus coupling elements
- 15 US1 ... USm: disconnection points of the infeed-bus coupling elements
- VBA: load-bus coupling elements
- VBA1 ... VBAn: load-bus coupling elements of the first energy bus
- VBA1' ... VBAn': load-bus coupling elements of the second energy bus

P a t e n t k r a v

1. Strømforsyningsindretning (SV1; SV2; SV3; SV3'; SV4; SV5; SV6; SV7) til forsyning af flere forbrugere (FE, FE1, ..., FEn) med jævnstrøm, hvor forbrugerne (FE; FE1, ..., FEn) er komponenter af styre- og sikringsteknikken og
 5 respektivt omfatter en logik eller en processor, hvor strømforsyningsindretningen har en første energibus, som omfatter en på hinanden følgende anbringelse af flere forbrugere langs en 2-polet busledning og en jævnstrømskilde (PS1; PS2; PS3), med hvilken forbrugerne kan forbindes via busledningen,
 10 hvor forbrugerne via busledningen er parallelkoblet med jævnstrømskilden, hvor busledningen (L1; L3) via forbruger-bustilkoblingselementer (VBA; VBA1 ... VBAn) er inddelt i bussegmenter (BS), hvor mindst en af forbrugerne (FE; FE1 ... FEn) er tilsluttet et af forbruger-bustilkoblingselementerne (VBA; VBA1 ... VBAn),

15 hvor hvert forbruger-bustilkoblingselement (VBA; VBA1 ... VBAn) omfatter koblingselementer (S1, S2) til elektrisk afbrydelse af busledningen (L1; L3), således at bustilkoblingselementerne (VBA; VBA1 ... VBAn) respektivt kan bringes i en grundtilstand og/eller i en første driftstilstand, hvor busledningen (L1; L3) er elektrisk afbrudt ved hjælp af det tilsvarende forbruger-bustilkoblingselement (VBA; VBA1 ... VBAn), og kan bringes i en anden driftstilstand,
 20 hvor bussegmenterne (BS) er elektrisk forbundet ved hjælp af det tilsvarende forbruger-bustilkoblingselement (VBA; VBA1 ... VBAn),

kendetegnet ved, at

25 strømforsyningsindretningen har en anden energibus, som omfatter en på hinanden følgende anbringelse af flere forbrugere langs en 2-polet busledning og en jævnstrømskilde (PS1'; PS2'), og at der ud over bustilkoblingselementerne er en buskoblingsenhed (K) til stede, som er udformet til valgfri kobling af den første energibus (B1, B2) med den anden energibus (B1', B2').

30 2. Strømforsyningsindretning (SV1, SV2, SV3, SV3', SV4, SV5, SV6; SV7) ifølge krav 1, **kendetegnet ved, at** det ved forbrugerne (FE1 ... FEn) drejer sig om feltelementer.

35 3. Strømforsyningsindretning (SV1, SV3, SV3', SV5, SV6) ifølge et af kravene 1 eller 2, **kendetegnet ved, at** den første energibus (B1) har en lineær topologi, og dens jævnstrømskilde (PS1) er den eneste jævnstrømskilde af den

første energibus (B1).

5 **4.** Strømforsyningsindretning (SV2, SV4) ifølge et af kravene 1 eller 2, **kendetegnet ved, at** det første (FE1) og n-te-forbruger-bustilkoblingselementet (FE1, FEn) af den første energibus er direkte forbundet med jævnstrømskilden (PS1) af den første energibus, således at busledningen (L1) har en første ringformet topologi.

10 **5.** Strømforsyningsindretning (SV3, SV3') ifølge et af kravene 1, 2 eller 4, **kendetegnet ved, at** busledningen (L1) af den første energibus er elektrisk forbundet med en yderligere jævnstrømskilde (PS2, PS3).

15 **6.** Strømforsyningsindretning (SV3, SV3') ifølge krav 5, **kendetegnet ved, at** et af forbruger-bustilkoblingselementerne (FE1 ... FEn), fortrinsvis n-te-forbruger-bustilkoblingselementet (VBAn) er direkte forbundet med den yderligere jævnstrømskilde (PS2, PS3).

20 **7.** Strømforsyningsindretning (SV4) ifølge et af kravene 1 til 6, **kendetegnet ved, at** den første energibus (B2) og den anden energibus (B2') har en ringformet topologi.

25 **8.** Strømforsyningsindretning (SV5) ifølge et af kravene 1 til 6, **kendetegnet ved, at** den første energibus (B1) og den anden energibus (B1') har en lineær topologi.

30 **9.** Strømforsyningsindretning (SV6) ifølge et af kravene 1 til 6, **kendetegnet ved, at** en energibus (B2, B2') med ringformet topologi og en energibus med lineær topologi (B1, B1') er koblet med hinanden ved hjælp af buskoblingsenheden.

35 **10.** Strømforsyningsindretning ifølge et af de foregående krav, **kendetegnet ved, at** forbruger-bustilkoblingselementet (VBA) både på den negative og på den positive potentialside af busledningen (L) har respektivt et første koblingselement (S1) til elektrisk afbrydelse af busledningen (L) og et andet koblingselement (S2) til tilkobling af forbrugeren (FE) til energibussen, hvor de første

koblingselementer (S1) er del af busledningen (L1), og de anden koblingselementer (S2, S3) er del af en forsyningsledning, der fører fra busledningen (L1) til forbrugeren (FE).

5 **11.** Fremgangsmåde til drift af en strømforsyningsindretning ifølge et af de foregående krav, især inden for baneteknikken,

kendetegnet ved, at

10 forbruger-bustilkoblingselementerne (VBA1 ... VBA_n) sekventielt bringes fra grundtilstanden til driftstilstanden, således at forbruger-bustilkoblingselementerne (VBA1 ... VBA_n) tilsluttes sekventielt ved forsyning med jævnstrømskildens (PS1, PS2, PS3) strøm.

15 **12.** Fremgangsmåde ifølge krav 11, **kendetegnet ved, at** strømmen fra jævnstrømskilden (PS1, PS2, PS3, PS1', PS2') indføres i busledningen (L1, L2) på begge sider.

20 **13.** Fremgangsmåde ifølge krav 12, **kendetegnet ved, at** der med henblik på indføring på begge sider anvendes mindst en yderligere jævnstrømskilde (PS2, PS2', PS3).

25 **14.** Fremgangsmåde ifølge krav 12, **kendetegnet ved, at** der med henblik på indføring på begge sider anvendes en energibus (B2, B2') med en ringformet topologi og en enkelt jævnstrømskilde (PS1, PS1').

30 **15.** Fremgangsmåde ifølge et af kravene 11 til 14, **kendetegnet ved, at** forbruger-bustilkoblingselementerne (VBA3, VBA4), som grænser op til det defekte segment (BS), bringes i den første driftstilstand i tilfælde af et defekt segment (BS) af busledningen (L1).

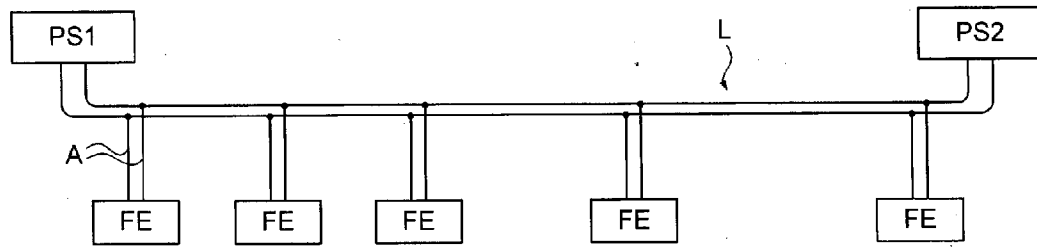


Fig. 1

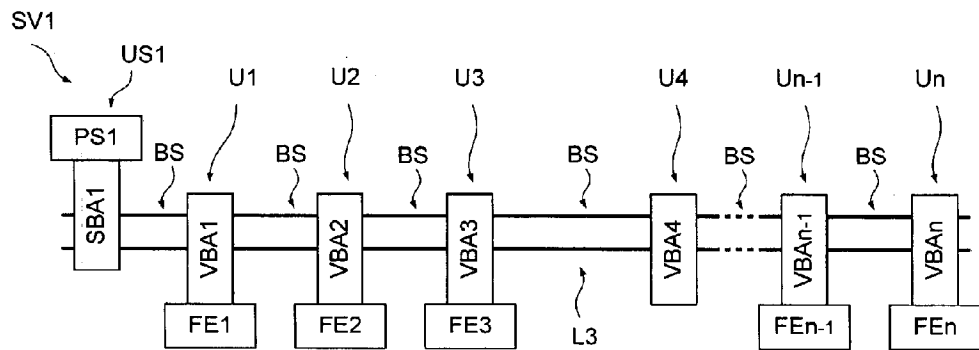


Fig. 2a

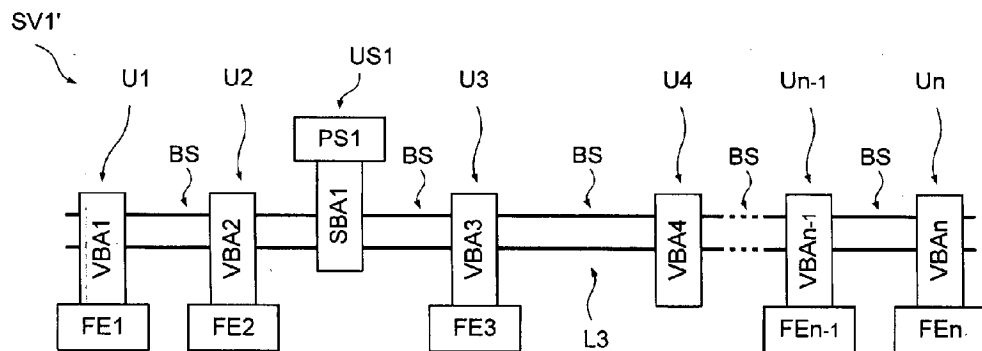


Fig. 2b

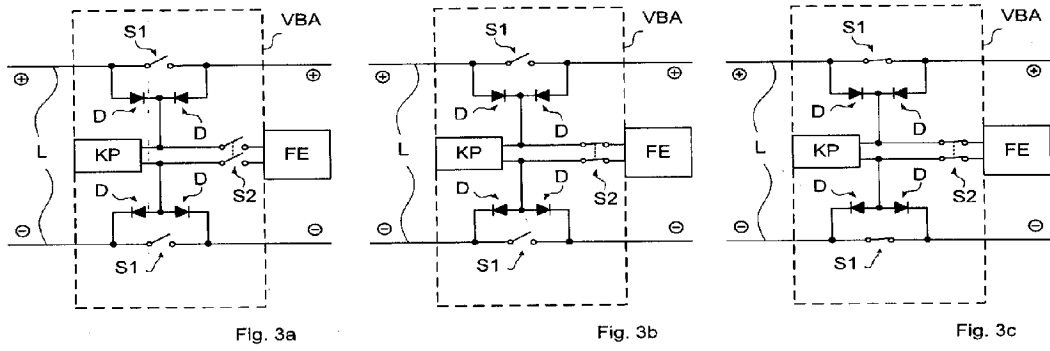


Fig. 3a

Fig. 3b

Fig. 3c

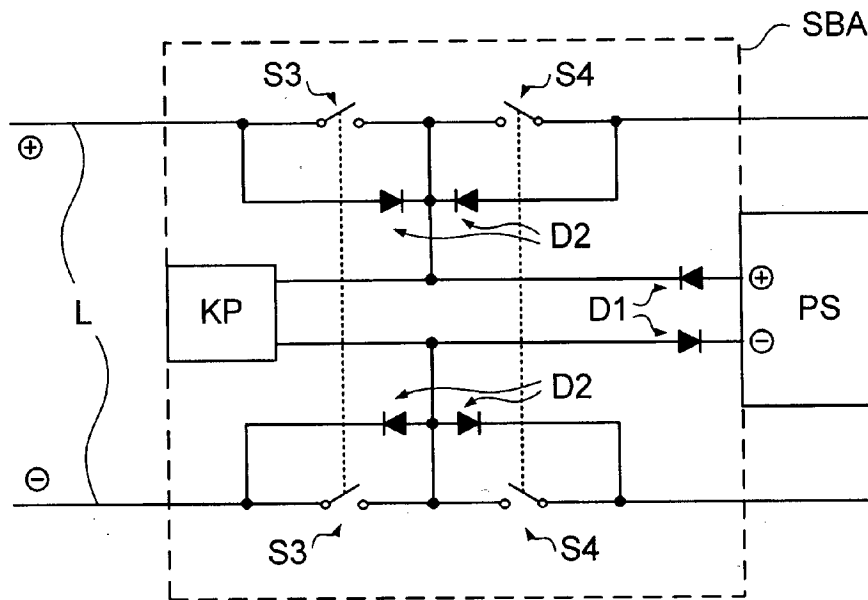


Fig. 4

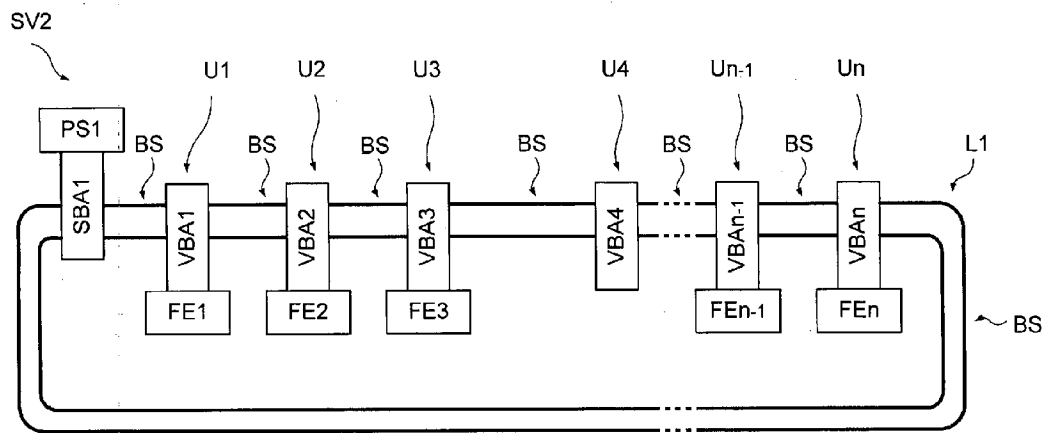


Fig. 5

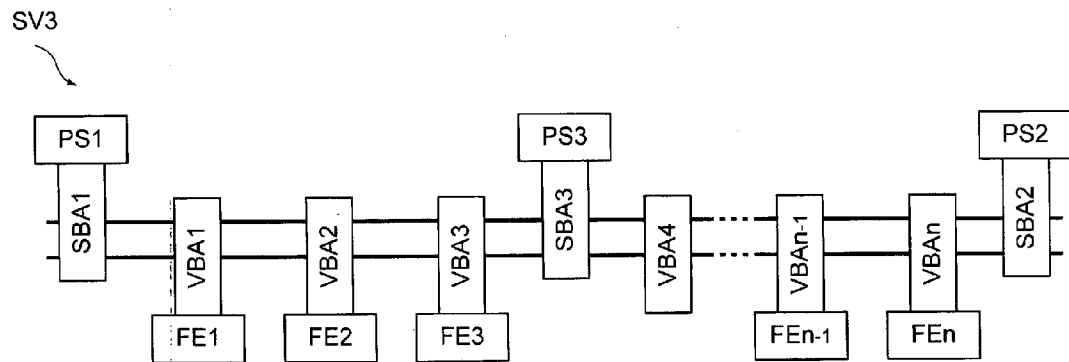


Fig. 6a

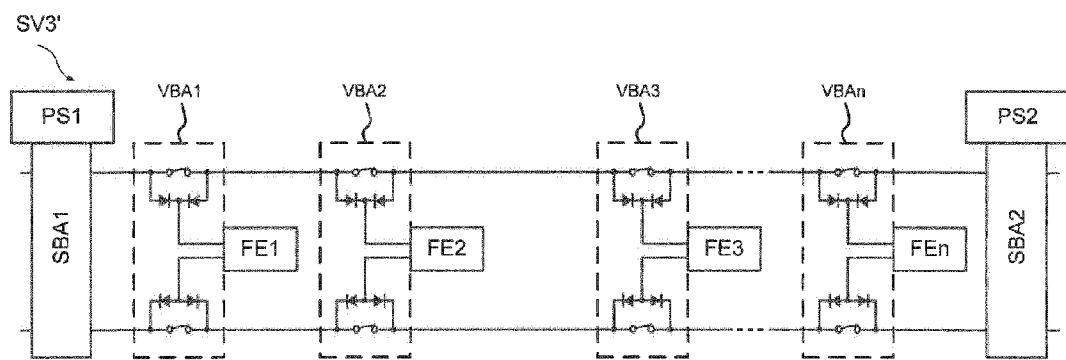
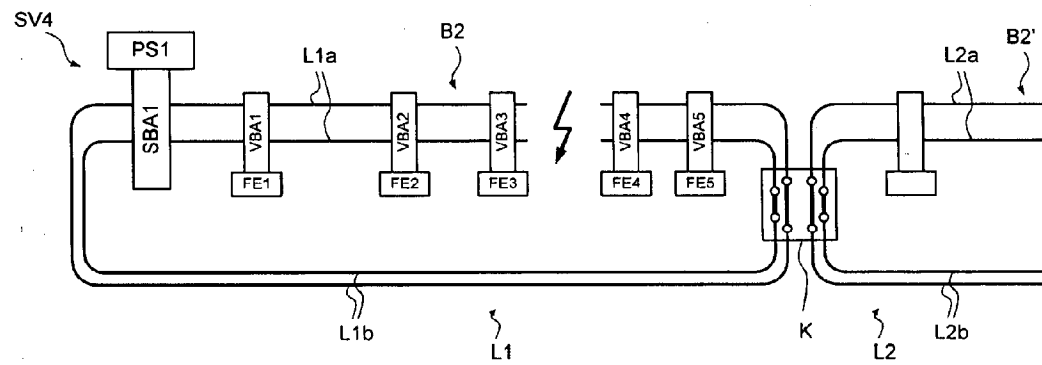
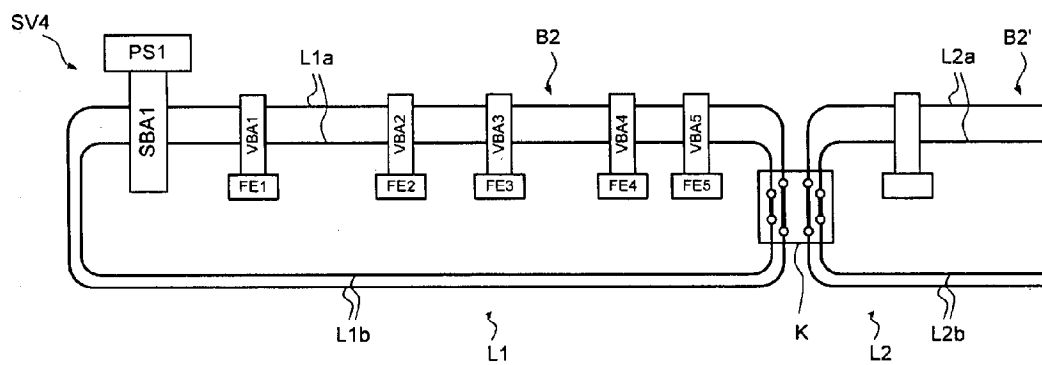
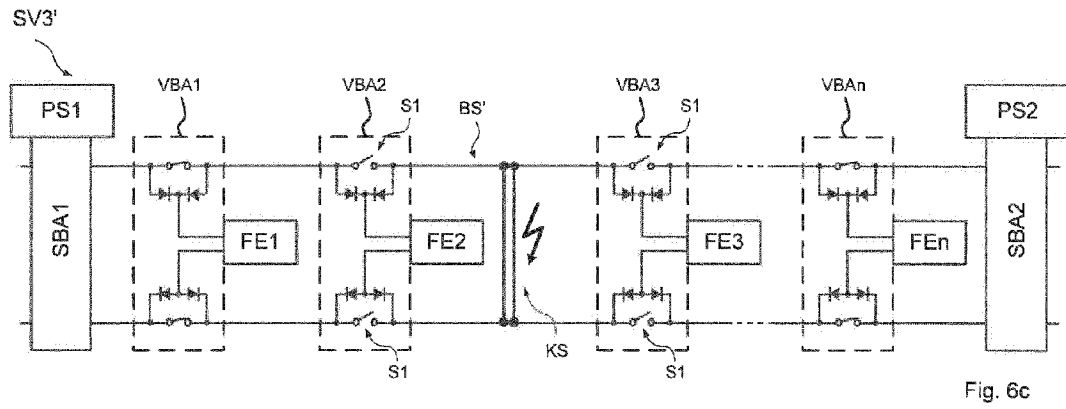


Fig. 6b



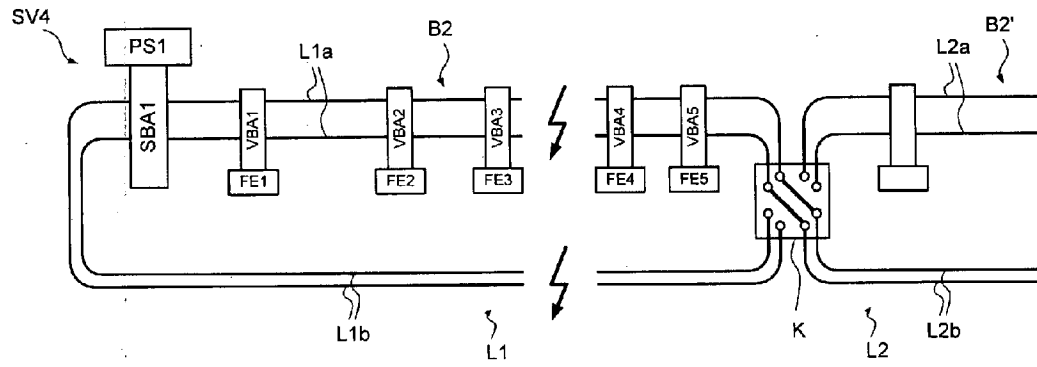


Fig. 7c

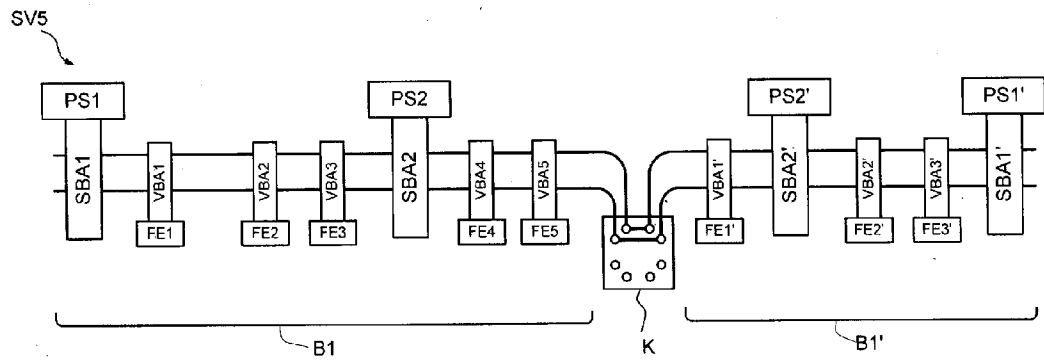


Fig. 8

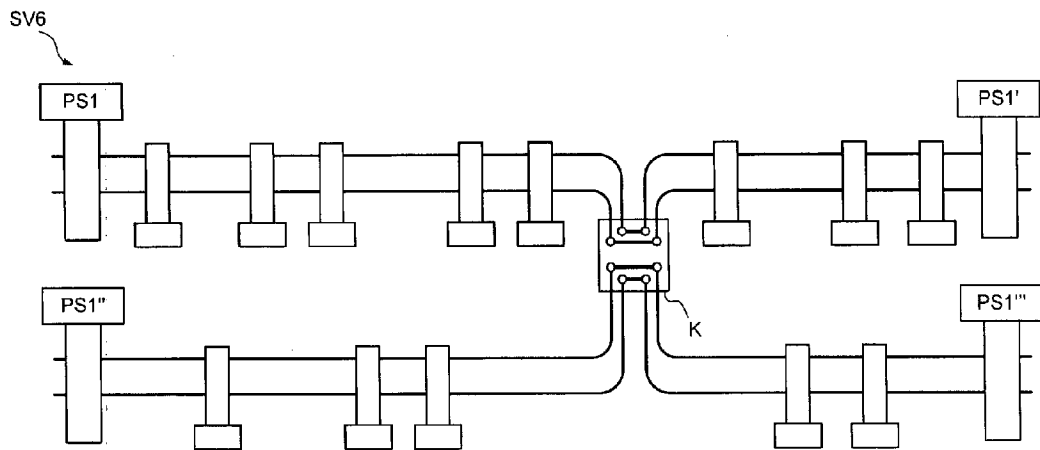


Fig. 9

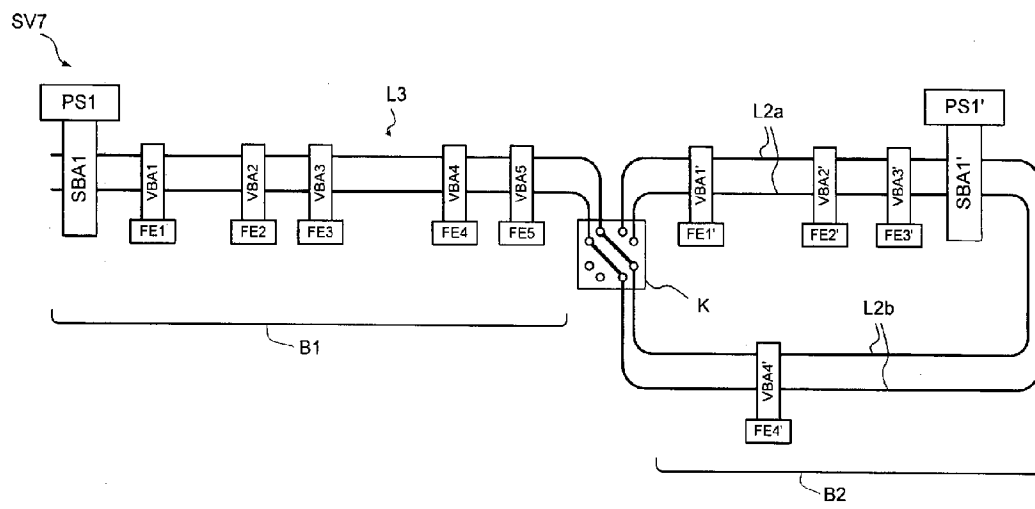


Fig. 10