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(54) **Titre : SYSTEME DE COMPRESSEUR DESTINE A UN VEHICULE FERROVIAIRE ET PROCEDE PERMETTANT DE FAIRE FONCTIONNER LE SYSTEME DE COMPRESSEUR DANS UN MODE D'URGENCE FIABLE**
(54) **Title: COMPRESSOR SYSTEM FOR A RAIL VEHICLE AND METHOD FOR OPERATING THE COMPRESSOR SYSTEM WITH SAFE EMERGENCY OPERATION**

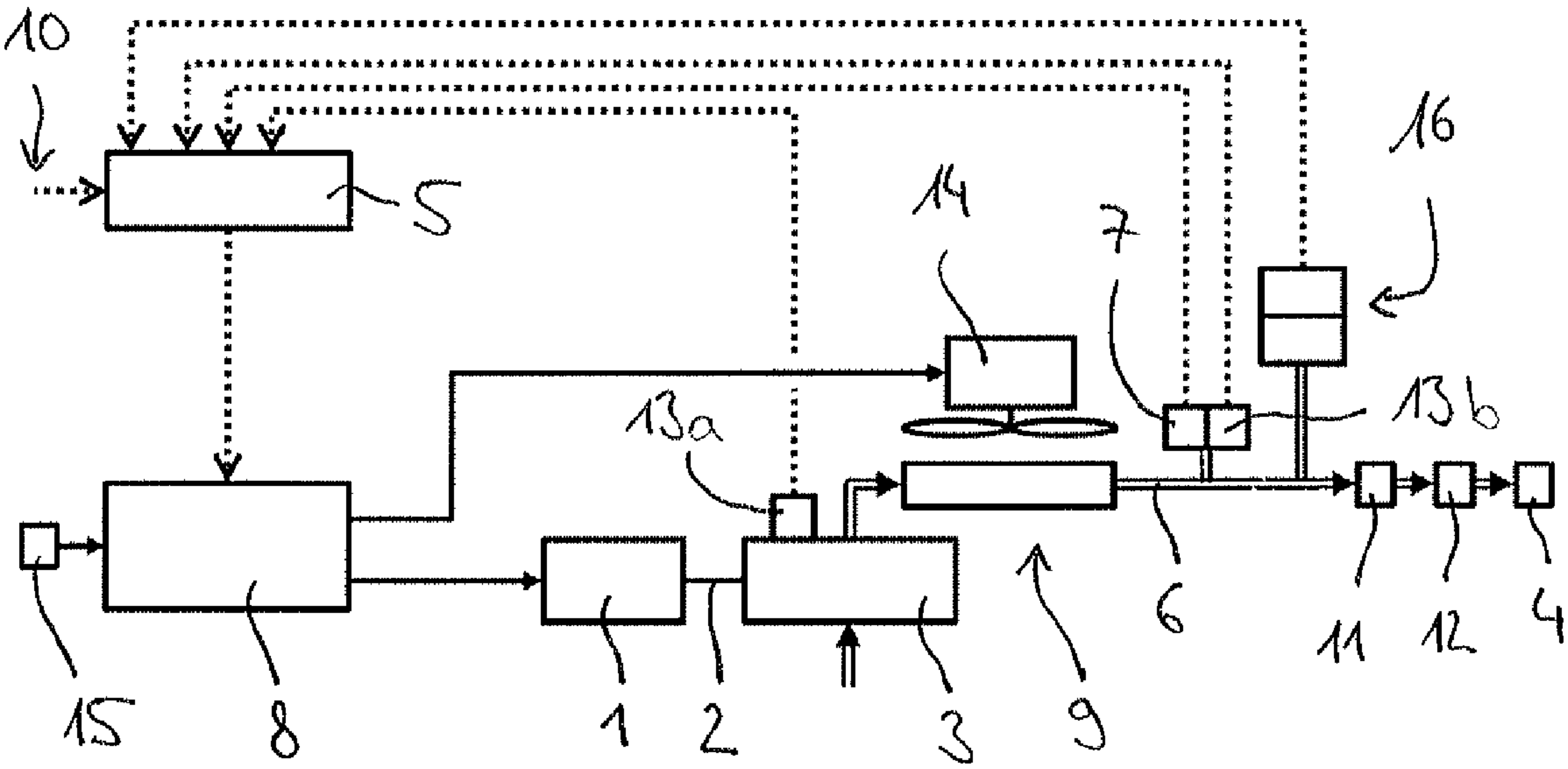

Fig. 1

(57) **Abrégé/Abstract:**
The invention relates to a compressor system for a rail vehicle, comprising a compressor (3), driven by an electrical machine (1) via a drive shaft (2), for producing compressed air for at least one compressed air tank (4), wherein the electrical machine (1) can be activated at least indirectly via a control device (5) for operating the electrical machine (1) at at least one nominal speed (n) between a maximum speed (m) and a minimum speed (i), wherein furthermore at least one pressure sensor (7) for determining the pressure for the control device (5) is disposed in a compressed-air-carrying line (6) downstream of the compressor (3). According to the

(57) **Abrégé(suite)/Abstract(continued):**
invention, a final control element (8) for continuously influencing the speed of the electrical machine (1) is disposed between an electrical supply (15) and the electrical machine (1), wherein the final control element (8) can be activated via the control device (5), and wherein a pressure switch (16) for monitoring the pressure in the at least one compressed air tank (4) and for influencing at least the speed of the electrical machine (1) is disposed in the compressed-air-carrying line (6) downstream of the compressor (3). Furthermore, the invention also relates to a method for controlling the compressor system according to the invention, wherein the compressor (3) is operated at a variable speed, assuming any intermediate value between the maximum speed (m) and the minimum speed (i), and wherein the pressure switch (16) monitors the pressure in the at least one compressed air tank (4) and has an indirect influence at least on the speed of the electrical machine (1).

ABSTRACT

The invention relates to a compressor system for a rail vehicle, comprising a compressor, driven by an electrical machine via a drive shaft, for producing compressed air for at least one compressed air tank, wherein the electrical machine can be activated at least indirectly via a control device for operating the electrical machine at at least one nominal speed between a maximum speed and a minimum speed, wherein furthermore at least one pressure sensor for determining the pressure for the control device is disposed in a compressed-air-carrying line downstream of the compressor. According to the invention, a final control element for continuously influencing the speed of the electrical machine is disposed between an electrical supply and the electrical machine, wherein the final control element can be activated via the control device, and wherein a pressure switch for monitoring the pressure in the at least one compressed air tank and for influencing at least the speed of the electrical machine is disposed in the compressed-air-carrying line downstream of the compressor. Furthermore, the invention also relates to a method for controlling the compressor system according to the invention, wherein the compressor is operated at a variable speed, assuming any intermediate value between the maximum speed and the minimum speed, and wherein the pressure switch monitors the pressure in the at least one compressed air tank and has an indirect influence at least on the speed of the electrical machine.

Compressor system for a rail vehicle and method for operating the compressor system with safe emergency operation

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FIELD OF THE INVENTION

The invention relates to a compressor system for a rail vehicle, comprising a compressor which is driven by an electric machine via a drive shaft and which serves for generating compressed air for at least one compressed-air vessel, wherein the electric machine can be controlled at least indirectly by means of a regulation device for operation of the electric machine at at least a rated rotational speed between a maximum rotational speed and a minimum rotational speed, wherein furthermore, in a compressed air-conducting line arranged downstream of the compressor, there is arranged at least one pressure sensor for determining the pressure for the regulation device. The invention also relates to a method for controlling the compressor system according to the invention.

BACKGROUND TO THE INVENTION

Compressors in rail vehicles are subject to a variety of, in part, conflicting demands, such as for example a high delivery output, adequate activation duration, low sound emissions, low energy consumption, a small structural space, and low purchase and life-cycle costs. Here, the compressor must satisfy extremely different demand profiles depending on the operating state of the rail vehicle. The typical problem in designing a compressor is that of finding the best comprise between these demands which is acceptable in all operating states of the rail vehicle. In general, electrically driven compressors are used in rail vehicles. The operation of the compressors takes the form of on/off operation with a constant rotational speed, the so-called rated rotational speed, between the lower activation pressure and the upper deactivation pressure. The compressor is dimensioned such that a predefined filling time is attained and a minimum activation duration during operation is not undershot.

From the generally known prior art, it emerges that, between the different operating states of the rail vehicle, there is no difference in the operation of the compressor. Here, the fan of the cooling system is subject to the same operating regime as the compressor, as the fan is generally directly jointly driven by the compressor.

It is also known that a more complex construction and more complex operation of the compressor system in relation to regular operation and in relation to the regular construction necessitate additional, in particular electronic components which may exhibit additional probability of failure or at least additional susceptibility to failure. In other words, the incorporation of additional electronics components in the compressor system also introduces into the compressor system the additional probability of failure of the individual electronics components. The probability of faults and the risk of failure of the compressor system are thus increased. Since the compressor system supplies compressed air to the brake system, a failure of the compressor system generally has the effect of bringing the rail vehicle to a standstill.

DISCLOSURE OF THE INVENTION

It is therefore the object of the present invention to optimize a compressor system and a method for operating the compressor system such that more energy-efficient operation of the compressor system, with a reduction in sound emissions, is possible without an increase in the probability of faults and risk of failure of the compressor system.

With regard to a device, the object is achieved, proceeding from a compressor system as per the preamble of Claim 1, in conjunction with the characterizing features of said claim. With regard to a method, the object is achieved as per Claim 6 in conjunction with the characterizing features thereof. Advantageous refinements of the invention emerge from the following dependent claims.

According to the invention, an actuator for the continuous manipulation of the rotational speed of the electric machine is arranged between an electrical supply and the electric machine, wherein the actuator can be controlled by way of the regulation device, and wherein, in the compressed air-conducting line arranged downstream of the compressor, there is arranged a pressure switch for monitoring of the pressure in the at least one compressed-air vessel and for manipulation of at least the rotational speed of the electric machine.

In other words, the actuator is situated upstream of the electric machine in the power flow, and is thus positioned ahead of the electric machine. The actuator permits operation of the electric machine at different rotational speeds. Frequency converters or inverters are particularly suitable for this purpose. In a manner dependent on frequency, the rotational speed of the electric machine and thus the operation of the compressor are adapted. However, the additional electronic components for regulating the rotational speed, in particular the additional sensors, cables and the actuator, give rise to an increase in the probability of faults and risk of failure of the compressor system.

By means of the pressure switch for monitoring the pressure in the at least one compressed-air vessel, the reliability of a compressor system of said type is increased, and the possibility of reliable emergency running operation is realized. Specifically, in the event of a drop in pressure, the pressure switch can indirectly manipulate at least the rotational speed of the electric machine. By means of a signal from the pressure switch to the effect that a certain lower pressure in the at least one compressed-air vessel has been undershot, the compressor can be activated, and in particular the rotational speed of the compressor can be increased, in order to increase the pressure in the at least one compressed-air vessel up to a certain upper pressure. Thus, the pressure switch manipulates at least the rotational speed of the compressor only when the pressure reaches either the minimum pressure or the upper deactivation pressure. When the minimum pressure is reached, the rotational speed is increased, wherein, when the upper deactivation pressure is reached, it is at least the case that the rotational speed is reduced, or the compressor is deactivated. In other words, in the event of a fault in the compressor system which leads to the minimum pressure in the at least one compressed-air vessel being reached, regular operation of the compressor is resumed such that the compressor is operated at rated rotational speed.

In a preferred exemplary embodiment, the pressure switch is operatively connected to the regulation device for the purposes of indirect manipulation of the rotational speed of the electric machine. In other words, the pressure switch transmits the generated signals to the regulation device, wherein the latter, preferably by way of an integrated control algorithm, adapts the rotational speed of the electric machine to the received signal.

In a further preferred exemplary embodiment, an isolating switch for separating the regulation device and the actuator from the electric machine is connected downstream of the actuator. In this case, the isolating switch is in particular arranged between the electrical supply and the electric machine, and thus constitutes a bridge both between the actuator and the electric machine and between the electrical supply and the electric machine.

Furthermore, the pressure switch is preferably connected to the isolating switch via an interposed control logic unit. The isolating switch is consequently independent of the regulation device and can be operated by way of the control logic unit, which receives signals from the pressure switch.

It is preferably provided that the regulation device at least indirectly controls a cooler unit which is arranged downstream of the compressor and which has a cooler fan, wherein a rotational speed of the cooler fan can be continuously adjusted by the regulation device. For this purpose, an actuator is preferably integrated in the cooler unit. It is alternatively also conceivable for the actuator to be at least positioned upstream of the cooler unit. It is likewise conceivable for an actuator to have two control outputs, such that both the electric machine and the cooler fan are controlled by way of a common actuator.

With regard to the method, the compressor is operated with a variable rotational speed which assumes any intermediate value between the maximum rotational speed and the minimum rotational speed, wherein the pressure switch monitors the pressure in the at least one compressed-air vessel and indirectly manipulates at least the rotational speed of the electric machine. By virtue of the fact that the cooling unit is not connected either directly or indirectly to the compressor, separate control of the cooling unit and thus separate adjustment of the rotational speed of the cooler fan are performed. It is advantageously also possible for the compressor and the cooler fan to be deactivated.

In a further exemplary embodiment, when the minimum pressure in the at least one compressed-air vessel is reached, the regulation device receives from the pressure switch a signal for triggering the actuator to operate the compressor at at least the rated rotational speed until the deactivation pressure is reached. In this way, it is possible in particular to counteract faulty sensors and/or cables. Specifically, the regulation device controls the actuator in accordance with the output of the pressure switch.

In a further exemplary embodiment, when the minimum pressure in the at least one compressed-air vessel is reached, the control logic unit receives from the pressure switch a signal for triggering the isolating switch and separating the regulation device and the actuator from the electric machine, wherein the compressor is operated, via the isolating switch, with the rated rotational speed until the deactivation pressure is reached. Depending on the position of the isolating switch, it is also possible to generate a rotational speed higher than the rated rotational speed for the electric machine. For this purpose, the isolating switch connects the electric machine directly to the electrical supply. Therefore, the regulation device cannot have any influence on the electric machine and thus on the rotational speed of the compressor. In this way, it is possible in particular for a failure or a fault of the regulation device as a whole, together with all associated sensors and the actuator, to be counteracted.

It is particularly preferably provided that, after the pressure of the at least one compressed-air vessel has fallen to the minimum pressure at least twice, the electric machine is operated with intermittent alternation between at least the rated rotational speed when the pressure falls to the minimum pressure and deactivation of the compressor when the deactivation pressure is reached. In other words, the rotational speed of the electric machine and thus the rotational speed of the compressor are varied no further, in order to maintain a relatively constant pressure in the at least one compressed-air vessel. It is however also conceivable for the compressor to be operated not with the rated rotational speed but with a maximum rotational speed in order to permit faster filling of the at least one compressed-air vessel.

BRIEF DESCRIPTION OF THE DRAWINGS

Further measures which improve the invention will be presented in more detail below in conjunction with the description of preferred exemplary embodiments of the invention and with reference to the figures, in which:

figure 1 shows a block circuit diagram of the compressor system according to the invention,

figure 2 shows a block circuit diagram of the compressor system according to the invention as per a second exemplary embodiment, and figure 3 shows two related diagrams, wherein a rotational speed of the compressor is plotted versus time in the upper diagram, and a pressure of the compressor is plotted versus time in the lower diagram.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

As per figure 1, a compressor system for a rail vehicle has an electric machine 1 which, via a drive shaft 2, drives a compressor 3 for generating compressed air. The compressed air generated by the compressor 3 is conducted via a compressed air-conducting line 6 to a cooler unit 9 which has a cooler fan 14. A pressure sensor 7 and a temperature sensor 13b are arranged downstream of the cooler unit 9 in the compressed air-conducting line 6. Furthermore, the compressed air-conducting line 6 issues into a pre-separator 11, downstream of which there is connected an air treatment system 12. The dried compressed air, which has been purified of particles, is then fed into a compressed-air vessel 4. Furthermore, in the compressed-air conducting line 6, there is arranged a pressure switch 16 for the monitoring of the pressure in the compressed-air vessel 4 and for the indirect manipulation of the rotational speed of the electric machine 1 and of the cooler fan 14.

A temperature sensor 13a, which is arranged at the compressor 3, and the temperature sensor 13b and the pressure sensor 7 all transmit the measured temperatures and the measured pressure to the regulation device 5. Furthermore, via a signal input 10, the regulation device 5 also receives signals from other sensors – not illustrated here – or from a train management system. Furthermore, the regulation device 5 is suitable for both controlling the rotational speed of the cooler unit 9 and transmitting signals to an actuator 8. The actuator 8, which is in the form of a frequency converter, sets the rotational speed of the electric machine 1 and thus the rotational speed of the compressor 3.

Furthermore, the actuator 8 has two outlets and thus also sets the rotational speed of the cooler fan 14 by way of the regulation device 5. In this case, the actuator 8 is, for the continuous manipulation of the rotational speed of the electric machine 1, arranged between an electrical supply 15 and the electric machine 1. In this case, when a minimum pressure e in the compressed-air vessel 4 is reached, the regulation device 5 receives from the pressure switch 16 a signal for triggering the actuator 8 to operate the compressor 3 at the rated rotational speed n until a deactivation pressure d is reached.

In Figure 2, an isolating switch 17 for separating the regulation device 5 and the actuator 8 from the electric machine 1 is connected downstream of the actuator 8. The pressure switch 16 is connected to the isolating switch 17 via an interposed control logic unit 18. In this case, when a minimum pressure e in the compressed-air vessel 4 is reached, the control logic unit 18 receives from the pressure switch 16 a signal for triggering the isolating switch 17 and separating the regulation device 5 and the actuator 8 from the electric machine 1. The compressor 3 is then operated, via the isolating switch 17, at the rated rotational speed n until a deactivation pressure d is reached.

Figure 3 graphically illustrates the above-described process in the event of a pressure drop in the compressed-air vessel 4 being measured by way of the pressure switch 16. In a region a, the compressor 3 is operated at a rotational speed between a minimum rotational speed i and the rated rotational speed n, wherein the pressure in the compressed-air vessel 4 is kept in a certain range. Thus, in the region a, the compressor 3 is in regulated operation. The rotational speed is variable and dependent on the situation.

In a region b, the pressure in the compressed-air vessel 4 and the rotational speed of the compressor 3 spontaneously drop. In other words, in the region b, a fault has occurred during regulated operation, which fault has led to a measured pressure drop.

When the pressure in the compressed-air vessel 4 reaches the minimum pressure e, the pressure switch 16 reacts and, in a region c, increases the rotational speed of the electric machine 1 and thus the rotational speed of the compressor 3 to the rated rotational speed n indirectly, either via the isolating switch 17 or via the actuator 8. Consequently, in the region c, the reaction of the pressure switch 16 occurs for the switchover of operation from regulated operation to non-regulated operation. There are two states of non-regulated operation. These are firstly the operation of the compressor 3 at the rated rotational speed n, and secondly the deactivation of the compressor 3. The cooler fan 14 (not illustrated here) is also operated analogously to the operation of the compressor 3.

After a deactivation pressure d has been reached in the compressed-air vessel 4, the compressor 3 is deactivated and is operated once again at a rotational speed between the minimum rotational speed i and the rated rotational speed n, such that the pressure in the compressed-air vessel 4 is kept in a certain range.

The invention is not restricted to the preferred exemplary embodiments described above. Rather, modifications thereto are also possible which are also encompassed by the scope of protection of the following claims. For example, it is also possible for the compressor 3 to provide a feed to a multiplicity of compressed-air vessels 4. It may also be provided that, when the minimum pressure e in the compressed-air vessel 4 is reached, the rotational speed of the electric machine 1 and thus the rotational speed of the compressor 3 are increased to a maximum rotational speed m rather than just the rated rotational speed n.

List of reference signs

1	Electric machine
2	Drive shaft
3	Compressor
4	Compressed-air vessel
5	Regulation device
6	Compressed air-conducting line
7	Pressure sensor
8	Actuator
9	Cooler unit
10	Signal input
11	Pre-separator
12	Air treatment system
13a, 13b	Temperature sensor
14	Cooler fan
15	Electrical supply
16	Pressure switch
17	Isolating switch
18	Control logic unit
a, b, c	Region
d	Deactivation pressure
e	Minimum pressure
i	Minimum rotational speed
m	Maximum rotational speed
n	Rated rotational speed

Claims

1. Compressor system for a rail vehicle, comprising a compressor (3) which is driven by an electric machine (1) via a drive shaft (2) and which serves for generating compressed air for at least one compressed-air vessel (4), wherein the electric machine (1) can be controlled at least indirectly by means of a regulation device (5) for operation of the electric machine (1) at at least a rated rotational speed (n) between a maximum rotational speed (m) and a minimum rotational speed (i), wherein furthermore, in a compressed air-conducting line (6) arranged downstream of the compressor (3), there is arranged at least one pressure sensor (7) for determining the pressure for the regulation device (5),
characterized in that an actuator (8) for the continuous manipulation of the rotational speed of the electric machine (1) is arranged between an electrical supply (15) and the electric machine (1), wherein the actuator (8) can be controlled by way of the regulation device (5), and wherein, in the compressed air-conducting line (6) arranged downstream of the compressor (3), there is arranged a pressure switch (16) for monitoring of the pressure in the at least one compressed-air vessel (4) and for manipulation of at least the rotational speed of the electric machine (1).

2. Compressor system according to Claim 1,
characterized in that the pressure switch (16) is operatively connected to the regulation device (5) for the purposes of indirect manipulation of the rotational speed of the electric machine (1).

3. Compressor system according to Claim 1,

characterized in that an isolating switch (17) for separating the regulation device (5) and the actuator (8) from the electric machine (1) is connected downstream of the actuator (8).

4. Compressor system according to Claim 3,
characterized in that the pressure switch (16) is connected to the isolating switch (17) via an interposed control logic unit (18).

5. Compressor system according to Claim 1,
characterized in that the regulation device (5) at least indirectly controls a cooler unit (9) which is arranged downstream of the compressor (3) and which has a cooler fan (14), wherein a rotational speed of the cooler fan (14) can be continuously adjusted by the regulation device (5).

6. Method for controlling a compressor system according to one of Claims 1 to 5,
characterized in that the compressor (3) is operated with a variable rotational speed which assumes any intermediate value between the maximum rotational speed (m) and the minimum rotational speed (i), wherein the pressure switch (16) monitors the pressure in the at least one compressed-air vessel (4) and indirectly manipulates at least the rotational speed of the electric machine (1).

7. Method according to Claim 6,
characterized in that, when the minimum pressure (e) in the at least one compressed-air vessel (4) is reached, the control logic unit (18) receives from the pressure switch (16) a signal for triggering the isolating switch (17) and separating the regulation device (5) and the actuator (8) from the electric machine (1), wherein the compressor (3) is operated, via the isolating switch (17), with the rated rotational speed (n) until the deactivation pressure (d) is reached.

8. Method according to Claim 6,
characterized in that, when the minimum pressure (e) in the at least one compressed-air vessel (4) is reached, the regulation device (5) receives from the pressure switch (16) a signal for triggering the actuator (8) to operate the compressor (3) at at least the rated rotational speed (n) until the deactivation pressure (d) is reached.

9. Method according to one of Claims 6 to 8,
characterized in that, after the pressure of the at least one compressed-air vessel (4) has fallen to the minimum pressure (e) at least twice, the electric machine (1) is operated with intermittent alternation between at least the rotational speed (n) when the pressure falls to the minimum pressure (e) and deactivation of the compressor (3) when the deactivation pressure (d) is reached.

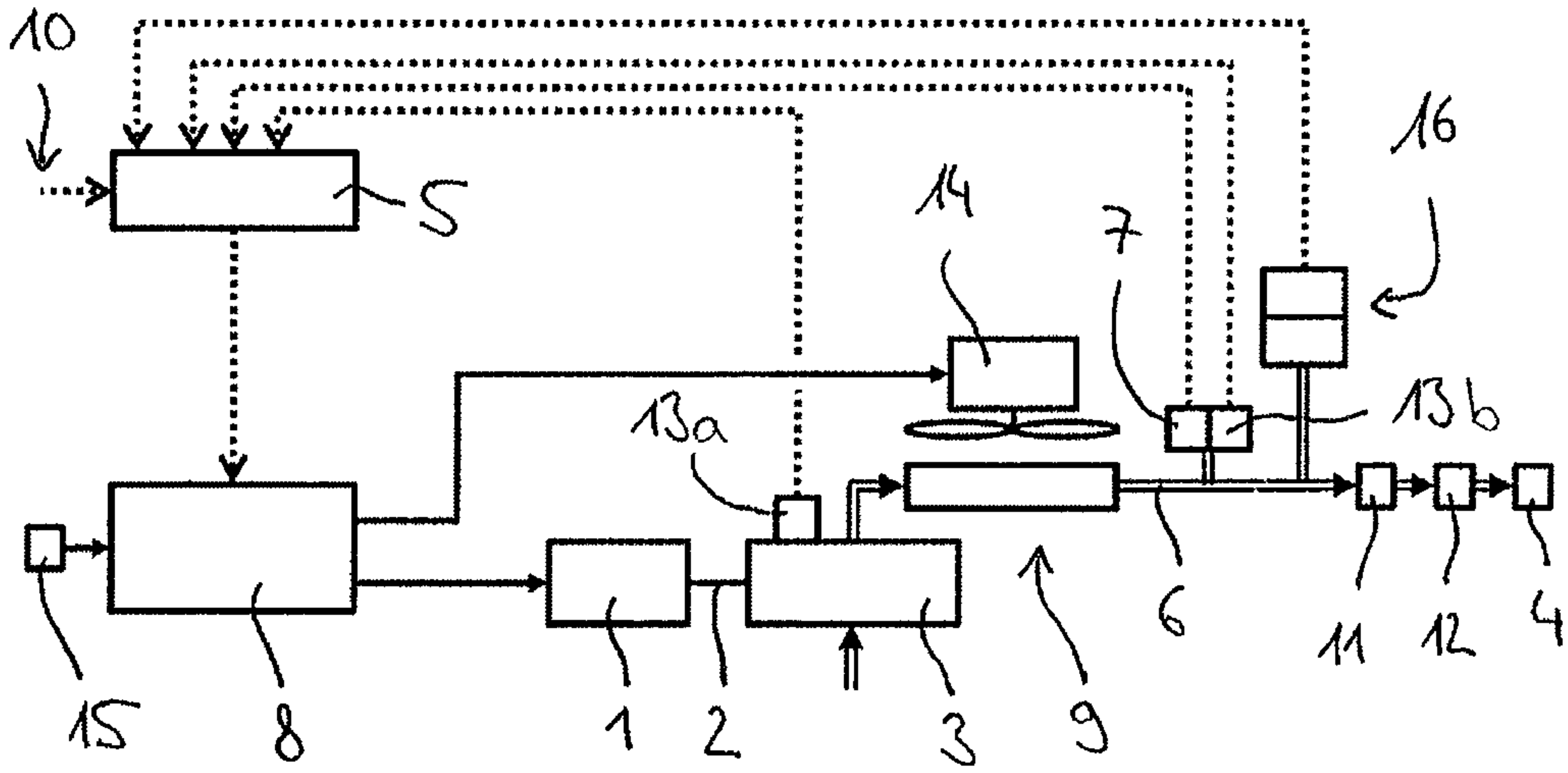
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Fig. 1

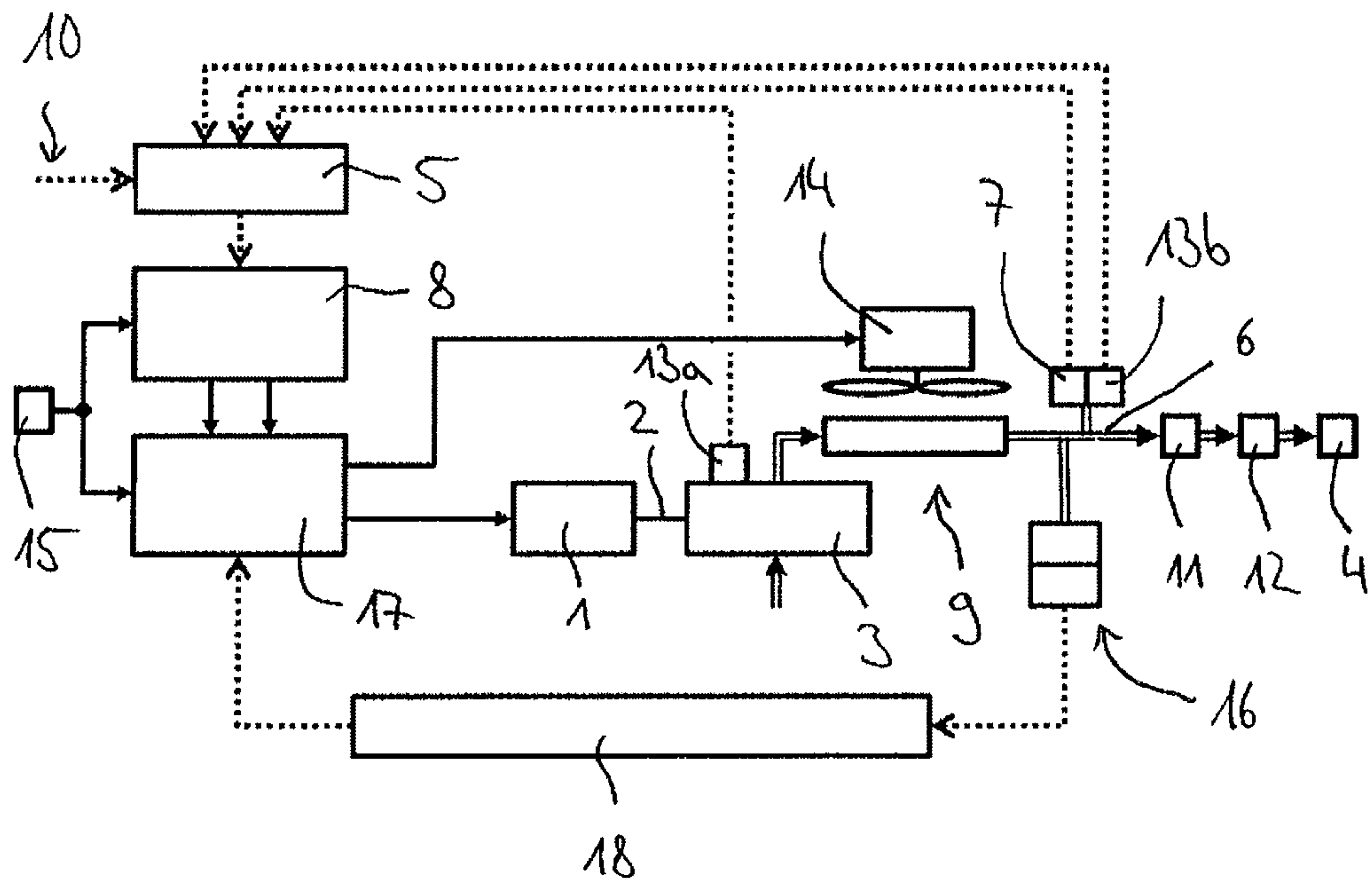
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Fig. 2

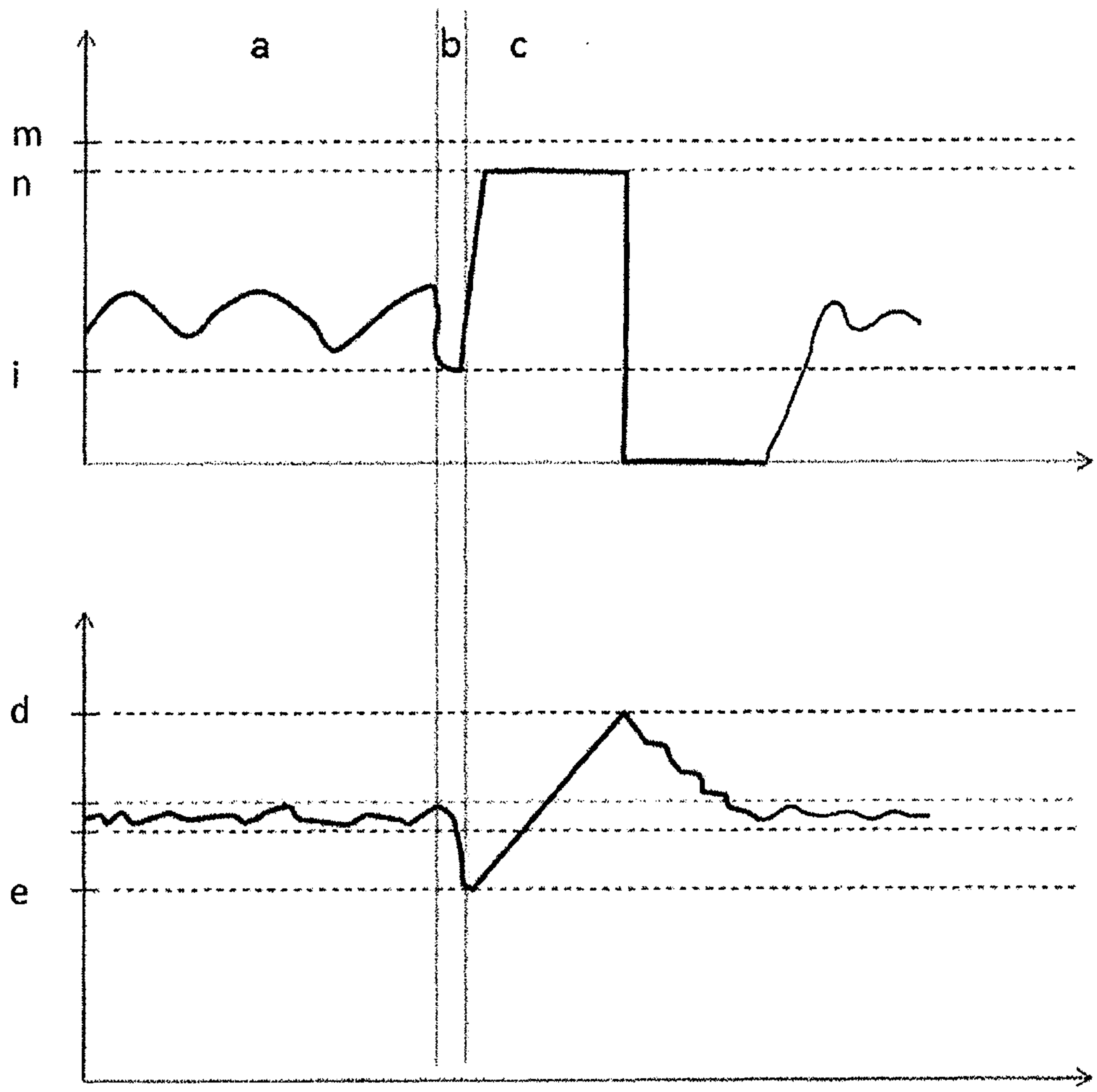

Fig. 3

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Fig. 1