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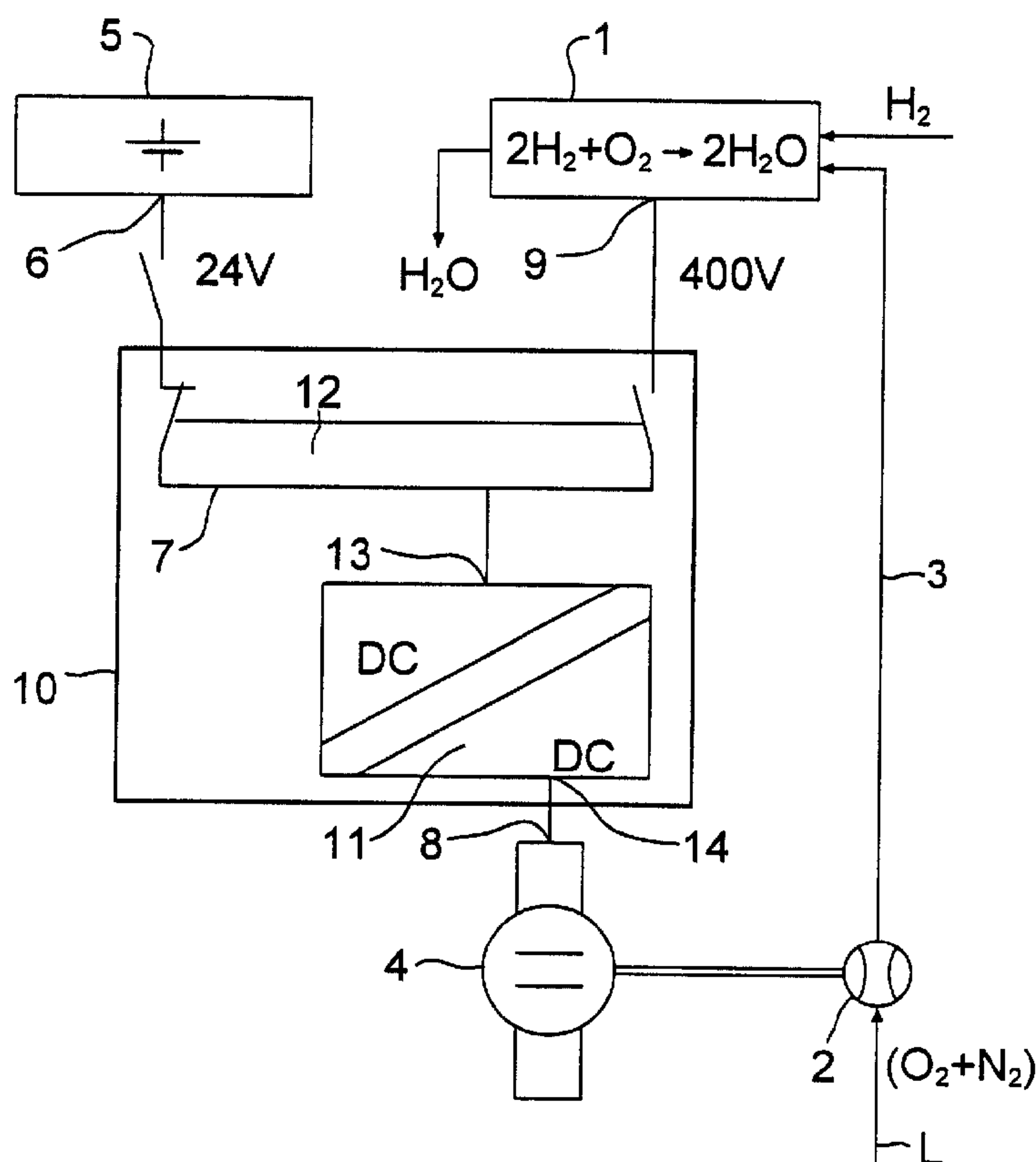
(72) Inventeurs/Inventors:
STUHLER, WALTER, DE;
WEISS, ALFRED, DE

(73) Propriétaire/Owner:
SIEMENS AKTIENGESELLSCHAFT, DE

(74) Agent: FETHERSTONHAUGH & CO.

(54) Titre : PROCÉDE PERMETTANT DE FAIRE DEMARRER UN DISPOSITIF A CELLULES ELECTROCHIMIQUES ET
DISPOSITIF A CELLULES ELECTROCHIMIQUES

(54) Title: METHOD FOR STARTING A FUEL CELL SYSTEM, AS WELL AS A FUEL CELL SYSTEM



(57) Abrégé/Abstract:

The invention relates to a method for starting a mobile fuel cell system, in particular for a vehicle, in which the air which is to be supplied to the system is conveyed during starting and operation of the system by a motor-powered compressor (2), in order to ensure the necessary operating pressure and, if required, additional humidifying of the air. The motor drive for the compressor (2)

(57) Abrégé(suite)/Abstract(continued):

has an electric motor (4, 20) which is supplied from a mobile starter battery (5) during the starting phase. The output voltage of the starter battery (5) is different to the operating voltage at the output of the fuel cell stack (1) of the fuel cell system, with a control device (10) being provided between the output of the starter battery (5) or of the fuel cell stack (1) and the motor input (8), which control device (10) interrupts the starting voltage supplied from the output (6) of the starter battery (5) and switches over to the output voltage of the fuel cell stack (1) when the output operating voltage of the fuel cell stack (1) reaches an adequate level.

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Abstract

Method for starting a mobile fuel cell system, as well as a mobile fuel cell system

The invention relates to a method for starting a mobile fuel cell system, in particular for a vehicle, in which the air which is to be supplied to the system is conveyed during starting and operation of the system by a motor-powered compressor (2), in order to ensure the necessary operating pressure and, if required, additional humidifying of the air. The motor drive for the compressor (2) has an electric motor (4, 20) which is supplied from a mobile starter battery (5) during the starting phase. The output voltage of the starter battery (5) is different to the operating voltage at the output of the fuel cell stack (1) of the fuel cell system, with a control device (10) being provided between the output of the starter battery (5) or of the fuel cell stack (1) and the motor input (8), which control device (10) interrupts the starting voltage supplied from the output (6) of the starter battery (5) and switches over to the output voltage of the fuel cell stack (1) when the output operating voltage of the fuel cell stack (1) reaches an adequate level.

Figure 1

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Description

Method for starting a fuel cell system, as well as a fuel cell system

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The invention relates to a method for starting a fuel cell system having a fuel cell stack, a compressor for supplying a working medium to the fuel cell stack, and an electric motor for driving the compressor. The invention also relates to a fuel cell system having a fuel cell stack, a compressor for supplying a working medium to the fuel cell stack, and an electric motor for driving the compressor.

DE 43 22 767 C2 discloses a fuel cell system and a method for starting a fuel cell system of the type mentioned initially. The fuel cell system described in this document is an air and hydrogen system. A compressor which can be powered by an electric motor is provided to compress the air in the known system. The electric motor is supplied from a mobile starter battery during the starting phase.

Since, in the prior art, the output voltage of the starter battery is different to the operating voltage of the fuel cell stack of the fuel cell system, which is present at the output of the fuel cell stack, a separate electric motor, which is designed for the higher voltage of the fuel cell stack, is provided as well as the starter motor in the prior art. Such an apparatus is relatively complex since it requires two separate electric motors, which must be coupled to the compressor, occupying space and volume.

The invention is based on the object of specifying a method for starting a fuel cell system, in which the operation of the compressor is simplified, and which

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requires less design complexity and occupies less space for the fuel cell system.

In accordance with one aspect of this invention, there is provided a method for starting a fuel cell system having a fuel cell stack, a compressor for supplying a working medium to the fuel cell stack, and an electric motor for driving the compressor, characterized in that the electric motor is initially fed with current from a starter battery, and then with current from the fuel cell stack.

10 The essence of the invention is to switch the power supply for the electric motor from the starter battery to the fuel cell stack and, if necessary, back again. The switching process takes place when the voltage at the output of the fuel cell stack reaches an adequate level. The
15 electrical connection between the output of the starter battery and the motor input is interrupted, and the motor input is switched to the output voltage of the fuel cell stack. A fuel cell stack is also referred to as Brennstoffzellen-Stack [fuel cell stack] in the German
20 specialist literature.

In a development of the invention, the fuel cell system is a mobile air and hydrogen system, in particular for a vehicle, such as a construction industry vehicle, a vehicle for use indoors, a bus or the like. The fuel cell
25 system is supplied with air as the working medium during starting and operation, and the air is conveyed by the motor-driven compressor in order to ensure the necessary operating pressure and, if necessary, additional humidifying of the air. One suitable fuel cell system is a PEM fuel
30 cell system with PEM fuel cells. In this case, PEM stands for proton exchange membrane or else polymer electrolyte membrane.

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During the starting phase of the fuel cell system,
the electric motor of the compressor is advantageously
supplied from

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the starter battery. During the starting phase, the fuel cell block does not yet develop any voltage, or does not yet develop the necessary voltage, in order to operate the electric motor.

5 In an advantageous development of the invention, a control device is provided for switching the power supply of the electric motor, which control device interrupts the electrical connection between the output of the starter battery and the motor input and
10 switches over the motor input to the output voltage of the fuel cell stack when the output voltage of the fuel cell stack reaches an adequate level.

The operating voltage of the electric motor advantageously corresponds to the voltage of the
15 starter battery, and the control device advantageously comprises a converter which regulates the output voltage of the fuel cell stack down to the operating voltage of the electric motor, or less. A current regulator is able to regulate the output voltage of the
20 fuel cell stack down to the operating voltage of the direct-current motor and, in the process, also advantageously maintain this direct-current motor at a constant rotation speed.

The control device advantageously has two
25 functions: firstly the selection and switching of the supplied operating voltage for the electric motor during the starting phase and during the operating phase of the system. And secondly, the advantageous permanent regulation of the motor, which is important
30 for optimized operation of the fuel cell stack, since the compressor is to provide reproducible and advantageously optimized power levels.

The switching from the starter battery to the output of the fuel cell stack advantageously takes
35 place when the output voltage of the fuel cell stack is higher than the voltage of the starter battery since, in this case, the converter just has to regulate the output voltage level of the fuel cell stack downward.

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The output voltage of the fuel cell stack is advantageously approximately twice as great as the voltage of the starter battery. This refinement of the invention allows the electrical and electronic components of the converter still to have small dimensions for a mobile system.

A further advantage can be achieved by the converter being a direct-current controller (DC/DC controller) and the electric motor being a direct-current motor.

In an alternative refinement of the invention, the electric motor is a synchronous motor or an asynchronous motor and the control device comprises a converter which is in the form of an inverter, for example a DC/three-phase AC inverter. Furthermore, the electric motor has two separate winding systems, with the first winding system being designed for the voltage of the starter battery, and the second winding system being designed for the higher voltage of the fuel cell stack.

The control device also provides the motor regulation and the switching and selection of the two voltage sources. The first winding, which is designed for the voltage of the starter battery, can be isolated from the voltage sources via disconnection elements. The disconnection elements can be controlled by the switching apparatus, in the form of a DC/three-phase AC controller. The second winding system, which is designed for the operating voltage of the fuel cell stack, is continuously connected to the controller output.

Current is expediently drawn from the starter battery only until the voltage level at the output of the fuel cell stack has reached a changeover value, which can be preset. This is greater than the voltage level of the starter battery.

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In order to protect the electrical components and the motor, the first winding system of the electric motor is expediently disconnected at the zero crossing.

In accordance with another aspect of this invention, there is provided a fuel cell system having a fuel cell stack, having a compressor for supplying a working medium to the fuel cell stack, and having an electric motor for driving the compressor, characterized in that the electric motor of the compressor can optionally be operated with current from a starter battery or with current from the fuel cell stack.

The fuel cell system is advantageously a mobile fuel cell system, which can be operated with air and hydrogen, for powering vehicles. The fuel cell system comprises at least one fuel cell stack, which in turn comprises a number of fuel cells. The fuel cells are supplied, for example, with hydrogen and compressed air via a respective inlet. An air compressor is connected to the inlet of the fuel cells and has a motor drive with an electric motor which can be supplied from a starter battery.

In a development of the invention, the motor is connected to the power sources via an electronic control device. The control device has a converter having an intermediate circuit, that is, for example, a direct-current controller or an inverter, depending on whether the electric motor of the compressor is a direct-current motor, an alternating-current motor, or a three-phase motor.

Advantageously, apart from its control function, the control device also has a switching function and thus has a switching apparatus, which is connected electrically upstream of the input of the converter.

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The output of the converter is expediently permanently connected to the input of the electric motor.

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If the control device is in the form of an inverter, for example a DC/three-phase AC controller, both the output of the starter battery and the output of the fuel cell stack can be permanently connected via decoupling diodes to the input of the DC/three-phase AC controller.

In a further advantageous refinement of the invention, the electric motor (which is in the form of a three-phase motor) of the compressor has two separate winding systems. In this case, the first winding system is designed to be supplied with the low voltage of the starter battery, and the second winding system is designed to be supplied with a higher voltage, namely the voltage of the fuel cell stack.

The first winding system, which is designed for the lower voltage, of the electric motor can expediently be disconnected as soon as a changeover voltage level, which could be dangerous to the sensitive first winding system, is reached. The actual disconnection apparatus is advantageously integrated in the electric motor, or the compressor motor.

The invention will be explained in more detail with reference to exemplary embodiments in the figures of the drawing, in which:

Figure 1 shows a fuel cell system having a direct-current compressor motor;

Figure 2 shows a fuel cell system having a three-phase synchronous motor or a three-phase asynchronous motor.

The mobile fuel cell system, which is first of all illustrated only schematically and with the fundamental components relating to the invention in figure 1, comprises a number of fuel cells, which are configured and illustrated as a fuel cell stack 1. Compressed air is supplied to the fuel cell stack 1 via a compressor 2 and a line 3.

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The compressor 2 is driven by an electric motor 4 which is supplied from a starter battery 5 during the starting or run-up phase of the fuel cell system, the output 6 of which starter battery 5 provides an operating voltage of 24 V, which is supplied to the motor input 8 via a cable 7. The motor input 8 is not only connected to the output 6 of the starter battery 5, but can also be connected to the output 9 of the fuel cell stack 1. For this purpose, a control device 10 is provided, which has a converter 11. The converter 11 is a direct-current controller (DC/DC controller) for the electric motor 4 (which is in the form of a direct-current motor) of the compressor 2.

The switching from the output 6 of the starter battery 5 to the output 9 of the fuel cell stack 1 takes place via a switching apparatus 12, whose switching response can be controlled by an output 13 of the control device 10. The output 14 of the converter 11 is permanently connected to the input 8 of the electric motor 4.

Figure 2 likewise illustrates a fuel cell system. However, the electric motor 20 for powering the compressor 2 is not a direct-current motor, but a three-phase synchronous motor or a three-phase asynchronous motor and has two separate winding systems 21, 22. The first winding system 21 is designed to be supplied with the output voltage from the starter battery 5, and the second winding 22 is designed to be supplied with the higher voltage from the fuel cell stack 1.

The output voltages at the outputs 6 and 9 of the voltage sources differ considerably in the exemplary embodiment illustrated in Figure 2. The starter battery 5 supplies an output voltage of, for example, 48 V. The fuel cell stack 1 is designed to produce the operating voltage of 400-680 V at its output 9.

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Decoupling diodes 27 are connected in the power cables between the output 6 of the starter battery 5 and the output 9 of the fuel cell stack 1 and the inputs 25 and 26 of the control device 10. The control device 10 has a converter 30 for the electric motor 20, which is in the form of an inverter (DC/three-phase AC controller).

Disconnection elements 31 are also integrated in the area of the electric motor 20 and can be activated via an output 32 of the control device 10 to isolate the winding system 21 from the output 33 of the converter 30. This is done when the fuel cell stack 1 reaches a voltage which is considerably higher than that of the starter battery. The fuel cell stack then supplies the direct-current section of the control device 10.

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Patent Claims

1. A method for starting a fuel cell system having a fuel cell stack (1), a compressor (2) for
5 supplying a working medium to the fuel cell stack (1), and an electric motor (4, 20) for driving the compressor (2),
characterized in that the electric motor (4, 20) is initially fed with current from a starter battery (5),
10 and then with current from the fuel cell stack (1).
2. The method as claimed in claim 1, characterized in that the fuel cell system is a mobile air and hydrogen system, and in that the fuel cell
15 system is supplied with air (L) as the working medium during starting and operation, and in that the air (L) is conveyed by the motor-driven compressor (2) in order to ensure the necessary operating pressure and, if necessary, additional humidifying of the air (L).
3. The method as claimed in claim 1 or 2,
20 characterized in that the electric motor (4, 20) of the compressor (2) is supplied from the starter battery (5) during the starting phase of the fuel cell system.
4. The method as claimed in one of claims 1 to 3,
25 characterized in that the voltage of the starter battery (5) is different to the operating voltage of the fuel cell stack (1).
5. The method as claimed in one of claims 1 to 4,
30 characterized in that, when the fuel cell stack (1) reaches an adequate output voltage, a control device (10) which is located between the output (6) of the starter

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battery (5) and/or the output (9) of the fuel cell stack (1) and the motor input (8) interrupts the starting voltage supplied from the output of the starter battery (5), and connects the output voltage of the fuel cell stack (1) to the electric motor (4, 20).

6. The method as claimed in one of claims 1 to 5, characterized in that the control device (10) comprises a converter (11, 30), in that the operating voltage of the electric motor (4, 20) corresponds to the voltage of the starter battery (5), and in that the converter (11, 30) regulates the output voltage of the fuel cell stack (1) down to at least the value of the operating voltage of the electric motor (4, 20).

7. The method as claimed in claim 6, characterized in that the rotation speed of the electric motor (4, 20) is permanently regulated by the converter (11, 30).

8. The method as claimed in one of claims 1 to 7, characterized in that the system switches over from the starter battery (5) to the fuel cell stack (1) as soon as the output voltage of the fuel cell stack (1) is higher than the voltage of the starter battery (5).

9. The method as claimed in one of claims 1 to 8, characterized in that the operating voltage of the fuel cell stack (1) is approximately twice as great as the voltage of the starter battery (5).

10. The method as claimed in one of claims 6 to 9, characterized in that the converter (11) is a direct-current controller, and the electric motor (4) is a direct-current motor.

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11. The method as claimed in one of claims 1 to 9, characterized in that the electric motor (20) is a synchronous motor or an asynchronous motor which has two separate winding systems (21, 22), in that the first winding system (21) is designed for the voltage of the starter battery (5), and the second winding system (22) is designed for the operating voltage of the fuel cell stack (1), and in that a control device (10) is provided which comprises a converter (30) which is preferably in the form of an inverter.

12. The method as claimed in claim 11, characterized in that the electric motor (20) is permanently connected to the output (33) of the converter (30), in that the second winding system (22), which is designed for the operating voltage of the fuel cell stack (1), is permanently connected to the output (33) of the converter (30), and in that the first winding system (21), which is designed for the voltage of the starter battery (5), can be isolated from the voltage sources (1, 5) via disconnection elements (31).

13. The method as claimed in claim 12, characterized in that the first winding system (21) of the electric motor (20) is disconnected at the zero crossing.

14. The method as claimed in one of claims 1 to 13, characterized in that current is drawn from the starter battery (5) only until the output voltage of the fuel cell stack (1) has reached a value which is greater than the voltage of the starter battery (5).

15. The method as claimed in one of claims 5 to 14, characterized in that a converter (11, 30) having an intermediate circuit is used as the control device (10),

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and in that the operating voltage at the output (9) of the fuel cell stack (1) is increased continuously, as a result of which the components in the intermediate circuit of the converter (11, 30) are raised to a higher operating voltage.

16. A fuel cell system having a fuel cell stack (1), having a compressor (2) for supplying a working medium to the fuel cell stack (1), and having an electric motor (4, 20) for driving the compressor (2), characterized in that the electric motor (4, 20) of the compressor (2) can optionally be operated with current from a starter battery (5) or with current from the fuel cell stack (1).

17. The fuel cell system as claimed in claim 16, characterized in that the fuel cell system is a mobile fuel cell system, which can be operated with air (L) and hydrogen (H₂), for a vehicle propulsion system, which comprises a number of fuel cells in a fuel cell stack (1) to which hydrogen (H₂) and compressed air (L) can be supplied via a respective inlet, and in that the air inlet of the fuel cell stack (1) is connected to the compressor (2), which is connected to the electric motor (4, 20) that can be supplied from the starter battery (5).

18. The fuel cell system as claimed in claim 16 or 17, characterized in that the input (8) of the electric motor (4, 20) can be connected or is connected via an electronic control device (10), which has a converter (11, 30), not only to the output (6) of the starter battery (5), but also to the output (9) of the fuel cell stack (1).

19. The fuel cell system as claimed in claim 18, characterized in that a switching apparatus (12) is provided, which is connected electrically upstream of the input (13) of the converter (11).

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20. The fuel cell system as claimed in claim 19, characterized in that inputs of the switching apparatus (12) which are connected to the starter battery (5) or to the fuel cell stack (1) can be switched over smoothly.

21. The fuel cell system as claimed in one of claims 18 to 20, characterized in that the output (14) of the converter (11) is permanently connected to the input (8) of the electric motor (4).

22. The fuel cell system as claimed in one of claims 16 to 21, characterized in that the electric motor (20) is in the form of a synchronous or an asynchronous motor and has two separate winding systems (21, 22), wherein the first winding system (21) is designed to be supplied with a low voltage, and the second winding system (22) is designed to be supplied with a higher voltage.

23. The fuel cell system as claimed in claim 22, characterized in that the output (6) of the starter battery (5) and the output (9) of the fuel cell stack (1) are permanently connected via decoupling diodes (27) to the input (25, 26) of a converter (30).

24. The fuel cell system as claimed in claim 22 or 23, characterized in that the first winding (21), which is designed for low voltage, can be disconnected.

25. The fuel cell system as claimed in claim 24,

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characterized in that disconnection elements (31) are provided, and are integrated in the electric motor (20).

Fetherstonhaugh & Co.
Ottawa, Canada
Patent Agents

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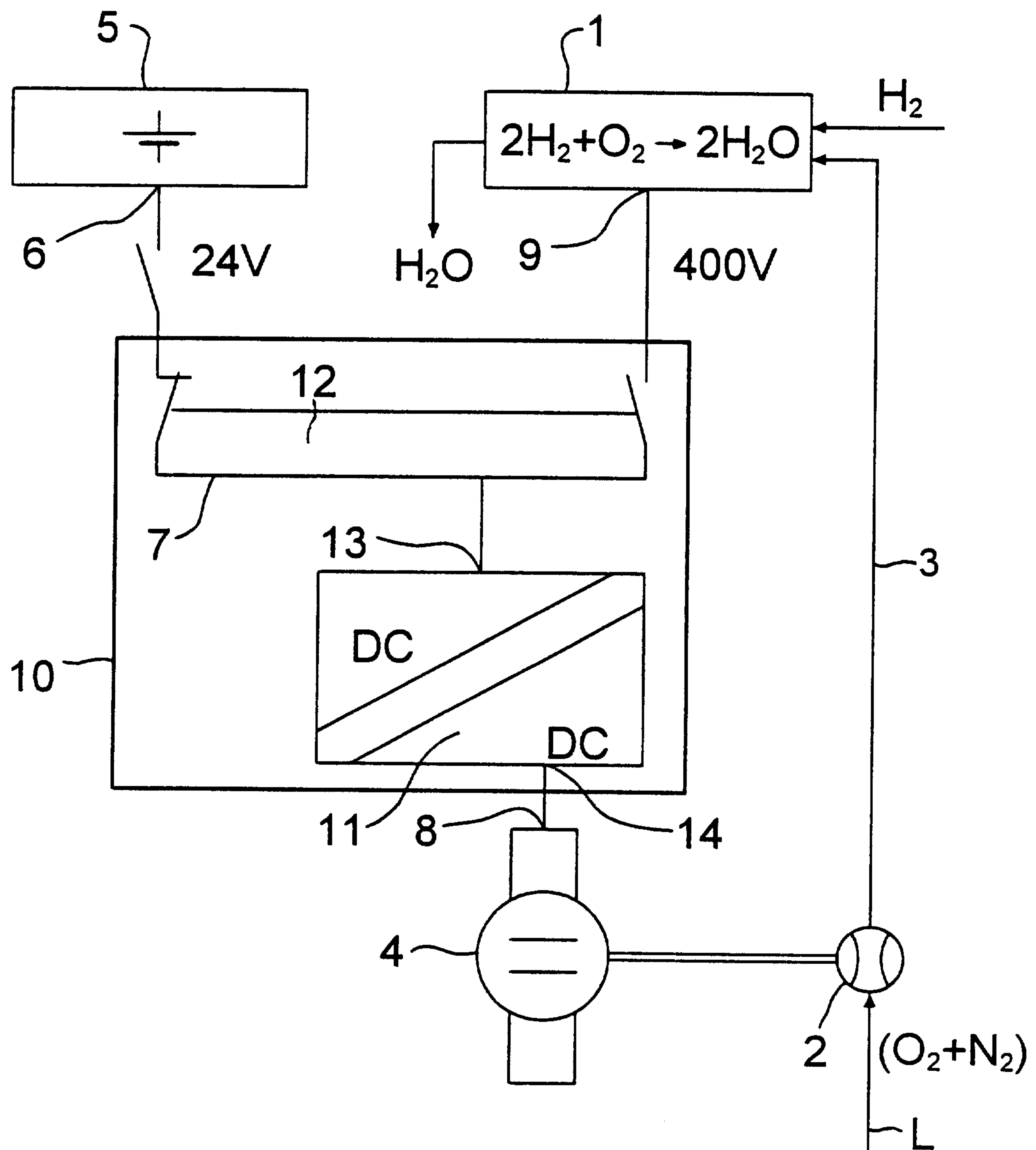


FIG 1

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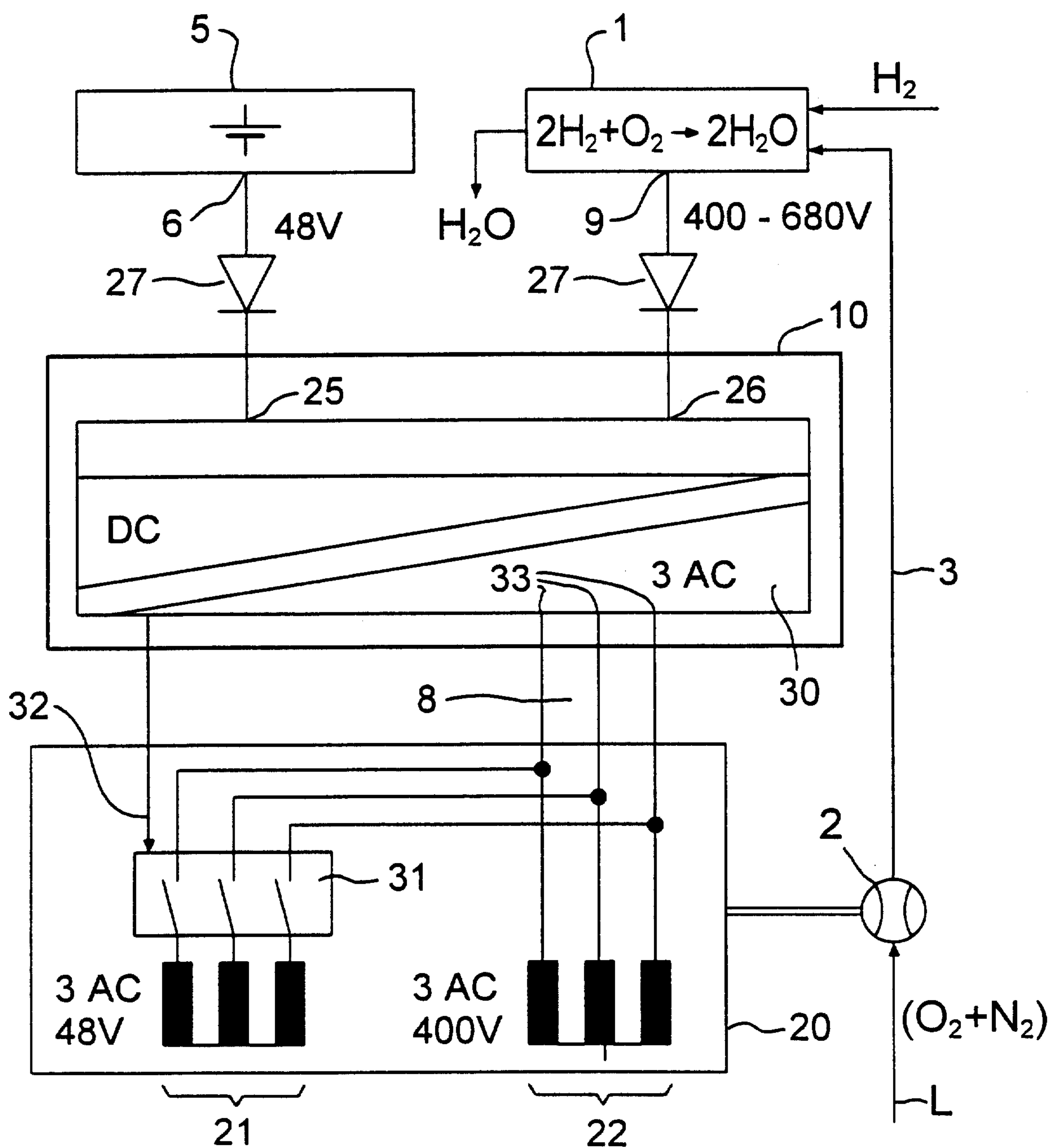


FIG 2

