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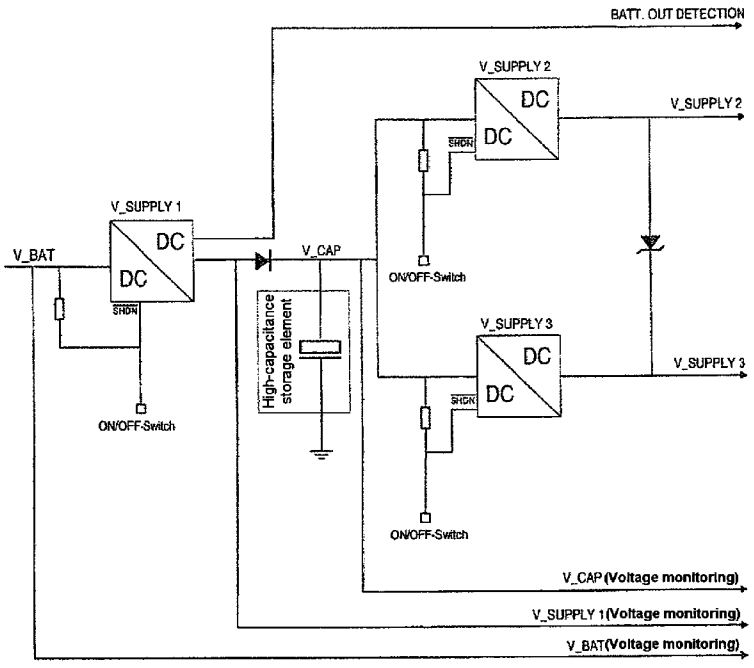
[Continued on next page]

(54) Title: UNINTERRUPTIBLE POWER SUPPLY FOR A MEDICAL APPLIANCE



(57) Abstract: One object of the invention is to provide an apparatus for metered supply of a liquid medicament having a power supply which not only allows the primary battery to be replaced without interrupting the insulin supply, but also makes it possible to bridge uncontrolled short-term interruptions in the current supply or voltage supply resulting from bouncing of the battery contacts, while also providing an adequate emergency power reserve.

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— *of inventorship (Rule 4.17(iv))*

Published:

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— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments*

Uninterruptible power supply for a medical appliance

Description:

The invention relates to an uninterruptible power supply for a medical appliance, in particular a medical appliance with a replaceable energy source for emitting medical liquids.

Electronic appliances are increasingly being used for self-medication in medical electronics, with these appliances generally been worn by the user directly on the body and supplying the medicament liquid continuously or quasi-continuously, as appropriate for the therapeutic requirement. By way of example, computer-controlled insulin pumps are being used for the treatment of diabetes mellitus, allowing the patient to be supplied with an insulin level which corresponds to the physiological characteristics of a non-diabetic, to a good approximation.

In order to allow the therapeutic end to be achieved, a series of fundamental requirements must be satisfied. Under all circumstances, it is necessary to avoid the power supply to the medical appliance failing without this being evident.

Since the apparatus is subject to considerable mechanical forces during normal daily use and its individual parts have different moments of inertia, it is possible in the event of a corresponding force influence, for example as a result of a sudden movement by the user, for the battery to be disconnected from the contact spring for a brief moment, causing a brief interruption in the voltage. Such inadvertent and possibly unnoticed resetting of the apparatus can have

serious consequences for the supply of the product, and patient safety.

Furthermore, it will be desirable to bridge relatively long failures of the power supply as can occur, for example, during replacement of the batteries, in order to avoid the need for monitored and time-consuming resetting of the insulin pump to a rest state.

Power supplies for insulin pumps are known from the prior art which allow more far-reaching so-called power management. Patent document EP 0168 472 discloses a fluid pump apparatus with a supporting energy source whose object is to allow the first power source to be supplied with sufficient energy, although the insulin pump functionality is greatly restricted in this operating mode. Power management systems are likewise known from the prior art which, when the energy source is identified as having been exhausted, change to an operating mode in which the insulin pump is stopped. The insulin pump therapy cannot be continued until a new battery has been inserted and the insulin pump has been set to the operating mode again, by the user.

The time at which the energy sources will become discharged can be predicated only imprecisely owing to the various influences acting on the stored rated energy of the energy source, for example storage conditions, temperature, age of the battery. If the energy cells for a patient become discharged during the night, the patient must be woken up from his sleep by requesting him to change the batteries. Even during the normal course of the day, it is desirable to have a certain emergency power reserve available, for example if a new energy source is not immediately available to the pump wearer.

One object of the invention is to provide an apparatus for metered supply of a liquid medicament having a power supply which not only allows the primary battery to be replaced without interrupting the insulin supply, but can also bridge uncontrolled short-term interruptions in the current supply or voltage supply resulting from bouncing of the battery contacts, and can also provide an adequate emergency power reserve.

The replacement of the energy source without interrupting the insulin supply also contributes to more convenient, more discrete and easier handling, which leads to higher patient confidence, since scarcely any control errors can occur if the infusion appliance is of a simple design and can be operated easily.

This object is achieved by the subject matter of the independent claim. Advantageous embodiments result from the dependent claims.

The invention is based on an apparatus for supplying a liquid substance, which apparatus is equipped with a replaceable energy source, for example a battery, which is connected via the battery contacts.

A supply apparatus of this generic type has a compartment for holding an energy source, for example a battery, a rechargeable battery or a fuel cell, which has a restricted life and must be replaced after a certain operating time. Primary cells such as these are produced in a charged form, and are generally provided as throwaway articles which are discharged only once. The electrical energy stored in the batteries is stored indirectly as a chemical compound and is released during the discharge process by Faraday oxidation and by reduction of electrochemically active materials. Supply gaps can occur when, for example, the battery is

replaced at the end of its life or if short-term interruptions, caused by inertia forces, affect the contact springs.

The solution according to the invention is based on a high-capacity storage element which is accommodated in the voltage supply and is also known by the expression SuperCap. In principle a SuperCap comprises an electrochemical double-layer capacitor surrounded by an electrolyte. When in the charged state, ion transport takes place, analogously to capacitor charging, under the influence of the electrical field. SuperCap makes it possible to provide components which behave like capacitances but have extraordinarily high storage densities of up to 10,000 W/kg.

The first energy source for supplying electrical energy may be a conventional primary cell, such as alkaline, lithium or other batteries that are known to those skilled in the art. However, secondary cells can also be used, which are charged in a charging apparatus and can be accommodated, analogously to a primary cell, in the accommodation compartment of the medical appliance or the pump.

Supply failures of the first power supply are directly buffered by the SuperCap by connecting the high-capacitance capacitor in parallel with a first energy source.

In one preferred embodiment, two different voltage circuits are provided, with the main voltage supply circuit in this case being buffered by the SuperCap. Secondary circuits which supply assemblies of secondary importance are not buffered.

In one particularly preferred embodiment, a SuperCap in the main supply provides the buffering for the entire power supply.

A second aspect relates to the SuperCap providing the peak supply. This makes it possible to reduce the space requirement and the dimensions of the power supply for peak loads, and this is associated with a considerable reduction in the power loss from the power supply. In addition, this results in an advantageous reduction in the internal resistance of the power supply.

A third aspect relates to compensation for inductive components of the primary cells by means of the SuperCap. Commercially available primary cells exhibit an increase in the inductive components as the state of charge decreases, which can have a negative influence on the response to power supply pulses, particularly at critical cell voltages, and can lead to uncontrolled operating states or voltage fluctuations.

The high-capacity storage element should have a minimum capacitance of about 0.5 Farad and should have housing dimensions which allow it to be integrated in the medical appliance.

A further aspect relates to the emergency power reserve of a medical appliance. For safe operation, it is necessary to know as well as possible when the stored energy will be discharged, in order to provide the user with sufficient time to replace the energy store. The stored rated energy in primary cells can be estimated only approximately because of various influences, such as the storage conditions, temperature range or battery age. However, the so-called emergency power reserve can be determined far more accurately when using a SuperCap solution. A simple state of charge monitor can be formed by means of an apparatus (5a) which measures the

charge taken from the SuperCap and adds it up by means of an integrator. The state of charge can be determined to a good approximation by means of a state of charge measurement, carried out by means of the voltage measurement during no-load operation (which is introduced briefly for this purpose) and by means of the elements 5a and 5b or by loading with a defined resistive load, since the SuperCap has a discharge curve like a capacitor element.

Further preferred embodiments of the invention are specified in the dependent claims, and will become evident from the following description, which is based on the figures, in which:

Figure 1 shows a general circuit arrangement with a first energy source and a charging apparatus for a high-capacity storage element;

Figure 2 shows a circuit for a power supply, by means of which a main circuit is buffered by a SuperCap and further voltages are emitted by means of appropriate DC/DC converters.

Figure 3 shows a circuit for a power supply for providing an uninterruptible appliance supply and a non-uninterruptible appliance supply; and

Figure 4 shows a flowchart of an infusion apparatus which is equipped with an uninterruptible power supply and allows the first energy source to be replaced without interrupting the operation of the insulin supply.

Figure 1 schematically illustrates a circuit arrangement for an uninterruptible power supply. The high-capacity element (2) is supplied with voltage via a charging apparatus (3) from a primary cell (1). The

load element, for example an insulin pump which draws heavy current, is represented schematically by a load on the voltage supply (4). The charging apparatus (3) may, in one simple embodiment, be in the form of a forward-biased diode or a DC/DC converter which transforms the battery voltage to a voltage level which corresponds not only to the optimum operating point for maintenance of the SuperCap (2) but also to the required operating voltage for the appliance. The state of charge of the high-capacity storage element can be monitored by means of a charge monitoring device.

Figure 2 shows a circuit design for an appliance feed according to the invention by means of which a commercially available primary cell, for example a 1.5 V alkaline or a 1.2 V NiMH cell at the input V_BAT. After conversion of the battery voltage by means of a voltage converter V_Supply 1 to an intermediate operating voltage V_Supply1, the state of charge of the SuperCap is maintained continuously via a diode and a feed supply for the voltage converters (V_Supply2, V_Supply3). The object of both of these is to provide voltage potentials for supplying various functional groups at the outputs of the voltage supply. Further output signals are provided for monitoring the voltage potentials, and are used for patient alarm purposes. When the primary battery is replaced, the voltage V_BAT fails. The Schottky diode between the voltage outputs V-Supply 2 and V-Supply 3 and is required if the voltage converter V_Supply 3 fails. In this case, voltage is supplied via the supply path V_Supply 2.

Figure 3 shows a power supply circuit which is used for buffering a main circuit by means of a SuperCap and to produce different required voltages by means of appropriate downstream DC/DC converters.

Figure 4 shows a flowchart of the individual procedure steps for an insulin pump with an uninterruptible power supply, from the normal operating state with the energy sources charged to the state in which all of the energy sources are completely discharged. During normal operation (RUN), a serviceable power supply is provided by the first energy source. If the battery or the rechargeable battery is removed from the battery compartment or if its state of charge is inadequate, the insulin supply is provided with the assistance of the SuperCap emergency reserves. A periodic warning is emitted to the user, requesting him to change the battery soon. If the necessary battery change is delayed until the SuperCap is approaching an incipient discharged state, the supply apparatus is first of all stopped, and the insulin supply ceases ("stop, no insulin supply, error is signalled"). If the SuperCap is discharged completely ("SuperCap discharged"), the appliance switches itself off automatically, and cannot be reset to normal operation until the first energy source has been replaced, and in fact only once the SuperCap is in the charged state again and after manual activation by the operator ("STOP-RUN change").

Claims:

1. Power supply for a medical appliance having a first replaceable energy source (1) for supplying electrical energy, a second energy source (2) for bridging supply gaps from the first energy source (1), and a charging appliance (3) which is fed from the first energy source and ensures that the second energy source has an adequate state of charge, characterized in that the second energy source (2) comprises a high-capacity storage element, ensuring an uninterruptible power supply for the medical appliance if the first energy source fails.

2. Power supply for a medical appliance according to Claim 1, characterized in that the first energy source (1) comprises at least one replaceable primary cell or secondary cell, which is connected via battery contacts.

3. Power supply for a medical appliance according to one of Claims 1 and 2, characterized in that the high-capacitor storage element is operated via a voltage converter in parallel with the first energy source, by means of which the medical appliance is provided with an uninterruptible main supply voltage.

4. Power supply for a medical appliance according to one of Claims 1 and 2, characterized in that an uninterruptible supply voltage and a non-uninterruptible supply voltage are provided.

5. Power supply for a medical appliance according to Claims 1 to 4, characterized in that the high-capacity storage element is operated in parallel with the first energy source, and is designed to adequately compensate for the inductive components of the first energy source.

6. Power supply for a medical appliance according to Claims 1 to 5, characterized in that the medical appliance is an insulin pump worn outside the body.

7. Power supply for a medical appliance according to Claims 1 to 5, characterized in that the medical appliance comprises an apparatus for detection of at least one physiological characteristic value.

8. Power supply for a medical appliance according to Claim 1, characterized in that the second energy source is formed by a high-capacity store with a capacitance of at least 0.5 F.

9. Power supply for a medical appliance according to the preceding claims, characterized in that a measurement device (5a) determines the state of charge of the high-capacity store by means of an energy measurement, and allows accurate predication of the uninterruptible power supply that is still ensured.

10. Power supply for a medical appliance according to the preceding claims, characterized in that the measurement device (5b) can estimate the remaining capacity of the high-capacity store, and a safe disconnection process is initiated if the user does not react to an alarm signal.

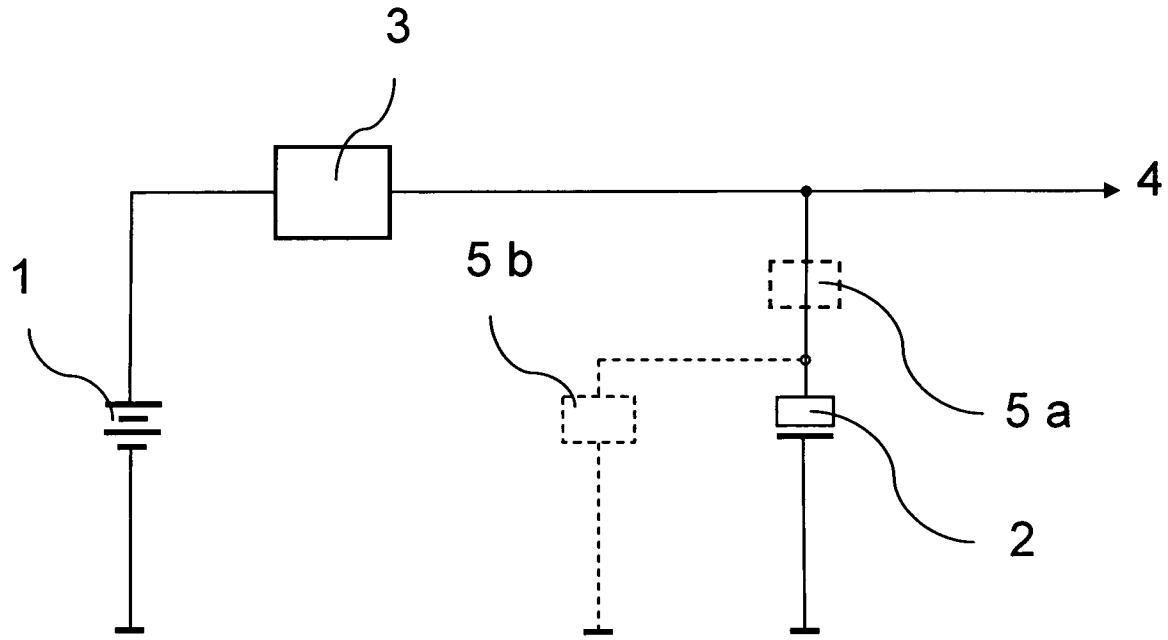

Fig. 1

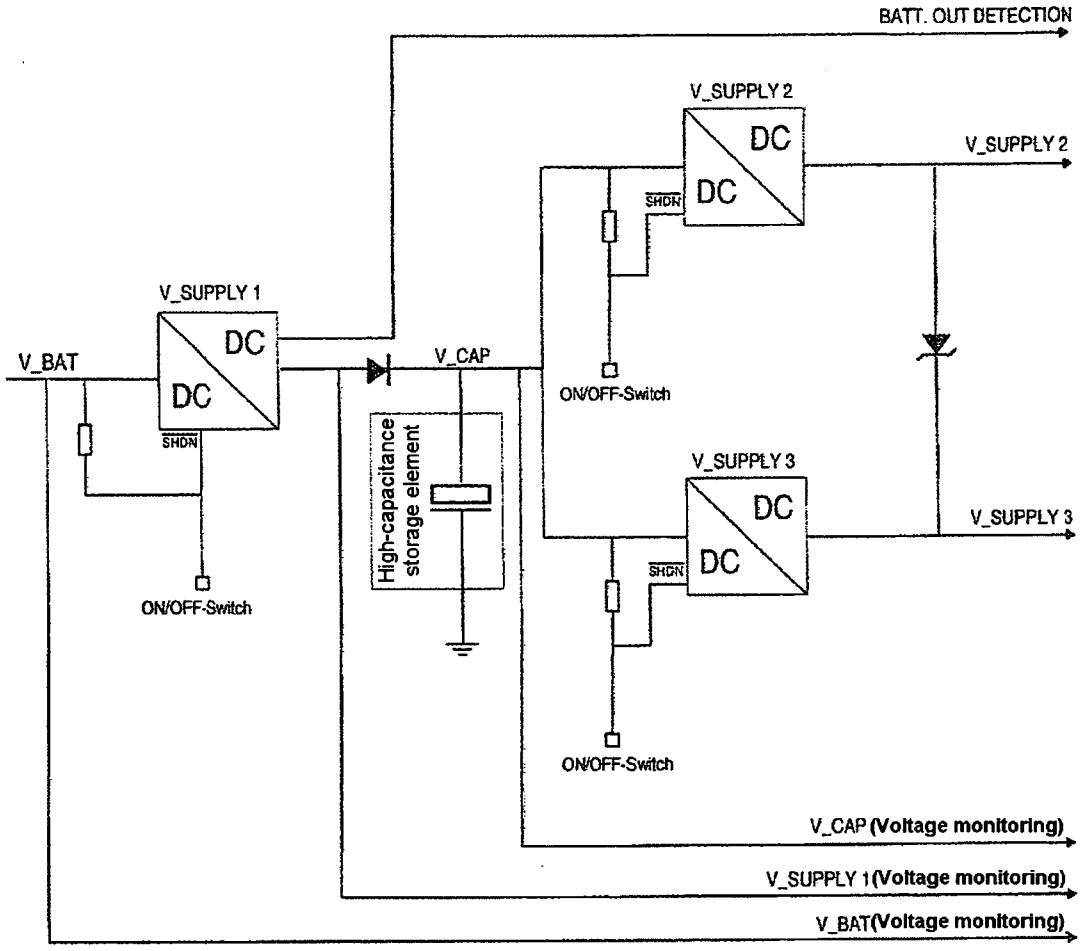
BATT. OUT DETECTION
V_SUPPLY 2
DC
DC
V_SUPPLY 2
SHDN
V_SUPPLY 1
DC
DC
V_BAT
V_CAP
SHDN
ON/OFF-Switch
High-capacitance storage element
V_SUPPLY 3
DC
DC
V_SUPPLY 3
SHDN
ON/OFF-Switch
ON/OFF-Switch
V_CAP (Voltage monitoring)
V_SUPPLY 1 (Voltage monitoring)
V_BAT (Voltage monitoring)

Fig. 2

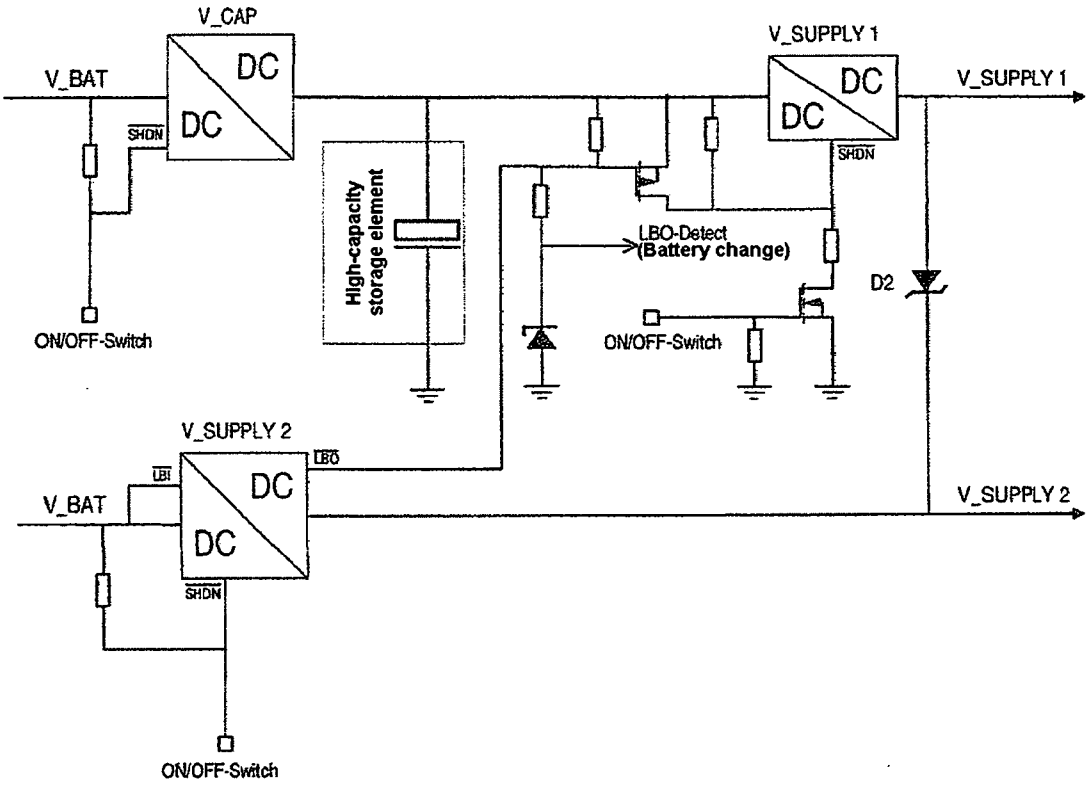
V_CAP
V_BAT
DC
DC
SHDN
ON/OFF-Switch
High-capacity storage element
V_SUPPLY 1
DC
DC
V_SUPPLY 1
SHDN
LBO-Detect
(Battery change)
D2
ON/OFF-Switch
V_SUPPLY 2
LBO
LBI
V_BAT
DC
DC
V_SUPPLY 2
SHDN
ON/OFF-Switch

Fig. 3

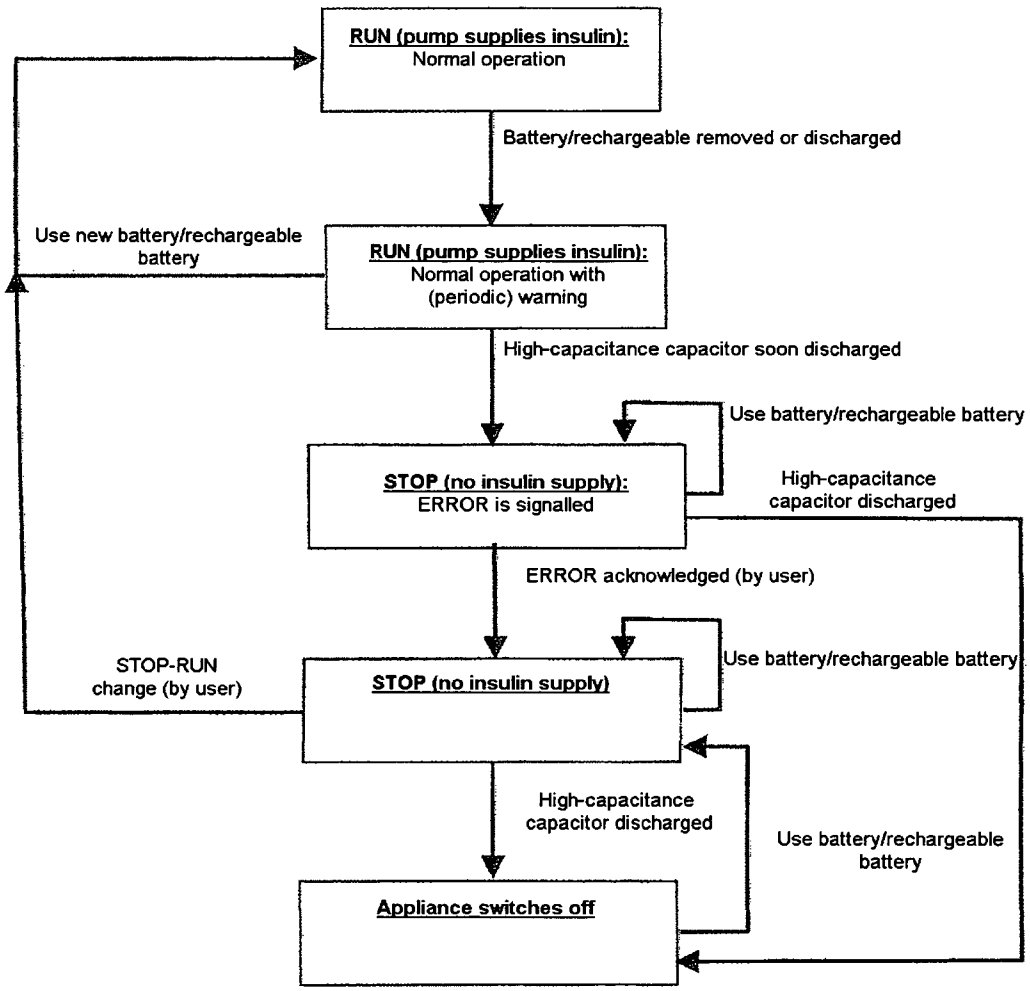
RUN (pump supplies insulin):
Normal operation
Battery/rechargeable removed or discharged
Use new battery/rechargeable battery
RUN (pump supplies insulin):
Normal operation with
(periodic) warning
High-capacitance capacitor soon discharged
Use battery/rechargeable battery
STOP (no insulin supply):
ERROR is signalled
High-capacitance
capacitor discharged
ERROR acknowledged (by user)
STOP-RUN
change (by user)
STOP (no insulin supply)
Use battery/rechargeable battery
High-capacitance
capacitor discharged
Use battery/rechargeable
battery
Appliance switches off

Fig. 4

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2007/009251

A. CLASSIFICATION OF SUBJECT MATTER
INV. H02J7/34 H02J9/06 H02J7/00 A61M5/172

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H02J A61M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	EP 1 646 124 A (SAMSUNG ELECTRONICS CO LTD [KR]) 12 April 2006 (2006-04-12) abstract paragraph [0047] - paragraph [0056] figures 1,4	1,2,4,5,8 6,7,9,10
X A	GB 2 395 373 A (NEC TECHNOLOGIES [GB]) 19 May 2004 (2004-05-19) abstract figure 1 page 2, line 28 - page 5, line 30	1,2,4 9,10
X A	FR 2 845 837 A (RENAULT SA [FR]) 16 April 2004 (2004-04-16) abstract page 3, line 1 - page 4, line 27 figure 3	1-4,8 5

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
27 February 2008	06/03/2008

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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2007/009251

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	abstract page 5, line 4 - page 7, line 21 figure 1	5
Y	WO 2006/006166 A (GROSS TECHNOLOGIES LTD [IL]; GROSS YOSSI [IL]; GIORINI-SILFEN SHIRLEY) 19 January 2006 (2006-01-19)	6,7
A	abstract paragraph [0073] paragraph [0118]	1
Y	US 6 459 242 B1 (BURES JEFFREY A [US] ET AL) 1 October 2002 (2002-10-01) abstract column 1, line 32 - line 56 paragraphs [0019], [0029], [0049] claims 1,5	9,10
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
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