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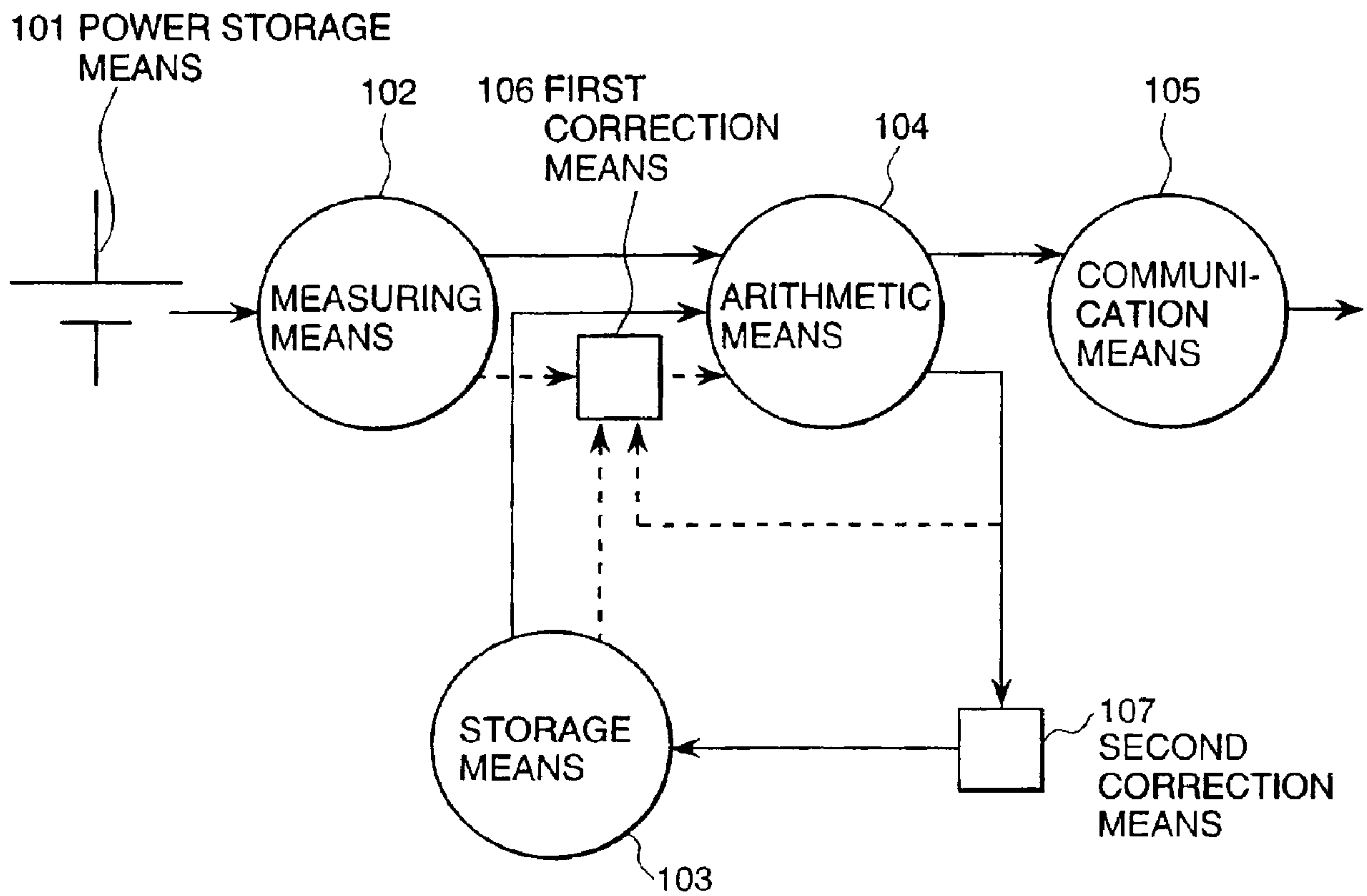


(57) Abrégé/Abstract:
A state detecting system which can detect a power storage state at high precision using less precise characteristic data for calculation of the power storage state. The state detecting system has a memory for storing characteristic data, a calculator and a corrector.

ABSTRACT

A state detecting system which can detect a power storage state at high precision using less precise characteristic data for calculation of the power storage state. The state detecting system has a memory for storing characteristic data, a calculator and a corrector.

STATE DETECTING SYSTEM AND DEVICE EMPLOYING THE SAME

This is a division of co-pending Canadian Patent Application No. 2,422,213 filed on March 14, 2003.

FIELD OF THE INVENTION

The present invention relates to a novel state detecting device for detecting states (e.g. charge condition, residual capacity in a power storage means such as a lithium secondary battery, a nickel hydride battery, a lead seal battery, and an electric double layer capacitor).

BACKGROUND OF THE INVENTION

In a power source unit, a distribution type power storage device and an electric vehicle employing power storage means, (e.g. a battery), a state detecting device is employed for detecting state of the power storage means in order to safely and effectively use the power storage means. The state of the power storage means represents state of charge (hereinafter abbreviated as "SOC" indicative of the amount of remaining charge, residual capacity, or state of health (hereinafter abbreviated as "SOH") indicative of amount exhausted or degree of deterioration.

The SOC in the power source unit can be detected by integrating a discharge current from a fully charged state and calculating a ratio of a charge amount residing in the power storage means (hereinafter referred to as "residual capacity") versus a maximum charge amount (hereinafter referred to as "full capacity"). However, many power storage means vary the full capacities depending upon SOH, temperature and so forth, making it difficult to accurately detect SOC with respect to secular change and environmental variation.

In order to solve this problem, Japanese Patent Application Laid-Open No. Heisei 10-289734 discloses a conventional residual capacity predicting method for battery deterioration. Fig. 10 is an illustration showing a residual capacity predicting method of the above-identified publication. In this method, an initial battery characteristic is corrected by a temperature correction coefficient derived on the basis of the temperature of the battery and a deterioration correction coefficient derived based on deterioration of the battery. A residual capacity of the battery is derived on the basis of the corrected battery characteristics, a discharge current during discharging and a terminal voltage.

In Japanese Patent Application Laid-Open No. Heisei 11-218567, there is shown a method for deriving a battery characteristic upon occurrence of deterioration by correcting an initial battery characteristic in relation to a temperature correction coefficient, an internal resistor deterioration correction coefficient, a capacitor deterioration correction coefficient.

In Japanese Patent Application Laid-Open No. 2000-166105, there has been disclosed a control unit for detecting a charge condition on the basis of charge and discharge current, detecting a power storage condition on the basis of a voltage and controlling a charge condition on the basis of such detections.

In Japanese Patent Application Laid-Open No. 2000-166109, there has been disclosed a charge condition detecting device for deriving an electromotive force based on a charge and discharge current, and voltage and for deriving a charge characteristic on the basis of the electromotive force.

In Japanese Patent Application Laid-Open No. 2001-85071, there is disclosed a temperature detecting device predicting respective temperatures of a set of battery modules on the basis of voltages between terminals and currents flowing therethrough.

In the residual capacity predicting method disclosed in the foregoing Japanese Patent Application Laid-Open No. Heisei 10-289734, influences for temperature or deterioration are taken in as temperature correction coefficient or deterioration correction coefficient for correcting parameters necessary for calculation of the residual capacity. These correction coefficients are derived through complicated derivation processes. Therefore, this method is concerned with correctness of the value per se of the correction coefficient and whether all battery characteristics are corrected.

In addition, the power storage means also has characteristics, (e.g. charge efficiency, memory effect, etc.) and makes correction in consideration of these characteristics in precision of residual capacity with high precision. On the other hand, the initial characteristics of the power storage means generally contain individual differences. Correction for individual differences is also necessary in prediction of residual capacity with high precision.

Namely, in order to perform state detection, such as prediction of residual capacity with high precision, it becomes necessary to effect accurate modeling of the characteristics to take in a plurality of parameters. Furthermore, correction associated with secular change or environmental variation of these parameters is performed.

Therefore, significant time and attention have to be paid for obtaining the initial characteristics and plurality of parameters of the power storage means. However, regardless of the complexity, the result of arithmetic operation is prediction on the basis of the theory or model of the battery characteristics. Therefore, there is still the concern of the correctness of the result of prediction with respect to a true value.

It has been found that in order to realize high precision state detection of the power storage means by simple characteristic data calculations, comparison of the result of state detection with the true value or logic and feeding this back to subsequent arithmetic operations to learn the difference provides correction. Since it is not possible to directly measure the state of the battery, such as SOC or SOH, an important problem is how to derive the true value or logic.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a state detection system to perform correction for feeding back correction information to make characteristic data useful in arithmetic operation for accurate detection of state.

The present invention is directed to a state detecting system comprising a storage means for storing characteristic data with respect to a power storage means arithmetically obtained on the basis of the measured information obtained by measuring a measuring object with respect to the power storage means by measuring means, calculation information relating to the arithmetic operation of the data, and set information preliminarily set relating to the characteristic data and the calculation information, an arithmetic means for calculating state information indicative of state of the power storage means on the basis of the measured information and set information and calculating correction information for performing correction by comparing a calculation result calculated and the set information, a first correcting means for correcting input of the arithmetic means on the basis of correction information obtained by the arithmetic means, or a second correcting means for correcting information stored or set in storage means based on correction information obtained by the arithmetic means.

In accordance with one aspect of the present invention there is provided a state detecting system for an electric storage device comprising: a memory medium storing storage information which includes characteristic data of an electric storage device, calculation information required for calculation for detection of a state of the electric storage device, and set information on a true set value or true logic based on a characteristic of the electric storage device or a phenomenon caused therein; a calculator which performs the calculation for detection of the state of the electric storage device on the basis of measured information obtained from a measuring instrument for measuring a parameter of the electric storage device required for detection of the state thereof and input information including the storage information and outputs correction information corresponding to the input information when a discrepancy is found in state detection information obtained by the calculation as a result of comparison of the state detection information and the set information; and a corrector correcting the input information on the basis of the correction information; wherein the correction information includes internal resistance information of the power storage device, the calculator outputs correction information corresponding to at least the internal resistance information when the discrepancy is found, and the corrector corrects the internal resistance information on the basis of the correction information corresponding thereto.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be understood more fully from the detailed description given hereinafter and from the accompanying drawings of the preferred embodiment of the present invention, which, however, should not be taken to be limitative to the invention, but are for explanation and understanding only.

Fig. 1 is a constructional illustration of a power source unit according to the present invention;

Fig. 2 is a block diagram showing a calculation process of the power source unit according to the present invention;

Fig. 3 is a circuit diagram showing an equivalent circuit of a power storage means according to the present invention;

Fig. 4 is a diagrammatic illustration showing a relationship between SOC and allowable charge and discharge current of power storage means according to the present invention;

Fig. 5 is a diagrammatic illustration showing a voltage variation upon charging by a pulse current of the power storage means according to the present invention;

Fig. 6 is a constructional illustration of the power source unit according to the present invention;

Fig. 7 is a diagrammatic illustration showing a relationship of OCV and SOC of the power storage means according to the present invention;

Fig. 8 is a constructional illustration of a distributed type power storage device of sunlight applied to the state detection system and the power source unit according to the present invention;

Fig. 9 is a constructional illustration of an automotive vehicle applied to the state detection system and the power source unit according to the present invention; and

Fig. 10 is a constructional illustration showing the conventional residual capacity predicting method according to the prior art.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention will be discussed hereinafter in detail in terms of the preferred embodiment of the present invention with reference to the accompanying drawings. In the following description, numerous specific details are set forth in order to provide a thorough understanding of the present invention. It will be obvious, however, to those skilled in the art that the present invention may be practiced without these specific details. In other instance, well-known structures are not shown in detail in order to avoid unnecessary obscurity of the present invention.

Fig. 1 is a constructional illustration of a power source unit according to the present invention. In Fig. 1, the reference numeral 101 denotes power storage means, 102 denotes measuring means, 103 denotes storage means, 104 denotes arithmetic means, 105 denotes communication means, 106 denotes first correction means and 107 denotes second correction means. The power storage means 101 is formed with a device having a power storage function, such as a lithium secondary battery, a nickel hydride battery, a lead seal battery, an electric double layer capacitor and so forth.

The measuring means 102 is formed with a sensor or an electric circuit measuring voltage, current, temperature, resistance, battery electrolyte concentration and so forth, to obtain measured information.

The storage means 103 is constructed with a memory device, such as an EEPROM, flash memory, a magnetic disk and so forth to store calculation information including at least one of characteristic data, calculation coefficient and calculation procedure, and set value to be considered as a preliminarily set true value relating to the calculation information or set information consisting of logic considered as true phenomenon.

The arithmetic means 104 is formed with a microprocessor, a computer or the like, and derives state information of the power storage means 101 on the basis of a measuring value of the measurement means 102 and a value of the storage means 103. On the other hand, the result of calculation and the set information are compared to calculate the correction information for correction amounts. As state of the power storage means 101, there are various abnormality, such as SOC, SOH, allowable current, continuous charge and discharge period, allowable temperature, overcharging, over discharging and so forth.

The communication means 105 is constructed with a device or circuit for communicating a serial number, such as CAN, Bluetooth and so forth or a device or circuit communicating an ON-OFF signal, such as photo-coupler, relay and so forth. Then, the result of calculation by the arithmetic means 104 is transmitted to other controller, display element or the like (not shown).

The first correction means 106 is constructed with a cache memory, a buffer memory, such as SRAM or the like, a register. Correction is performed by varying a value of the measuring means 102, a value of the storage means 103, a result of calculation of the arithmetic means 104 on the basis of a correction value derived by the arithmetic means 104.

The second correction means 107 is constructed with a writing circuit of EEPROM, flash memory and so forth as the storage means 103 or a writing circuit of the magnetic disk or the like and re-writes the value in the storage means 103 based on the correction value calculated by the arithmetic means 104.

While the first correction means 106 and the second correction means 107 are employed in the shown embodiment, it is possible to use one of these correction means or to employ other construction. On the other hand, by employing a microcomputer, in which an A/D converter, a flash memory, a microprocessor, a communication circuit are integrated on the same device, the measuring means 102, the storage means 103, the arithmetic means 104, the communication means, the first correction means 106 and the second correction means 107 can be integrated on the same device. On the other hand, these can be used in common with another control unit.

With the shown embodiment, the result of calculation per se is compared with the set value or the set information set as logic to perform correction with feed back to subsequent arithmetic operations learning the difference between the result of calculation and the set value or the set information. Therefore, it becomes possible to realize the state detection method and state detection system of the power storage means which is high accuracy with less accurate characteristic data used in arithmetic operation.

Fig. 2 is a block diagram showing a state detection method of the power storage means according to the present invention. In Fig. 2, in a step of measuring and reading, voltage, current, temperature, resistance, electrolyte concentration and so forth of the power storage means 101 is measured to read the measuring value of the first correction means 106 or the arithmetic means 104 or a value of the storage means 103. In calculation, the state of the power storage means 101 is calculated on the basis of the read value. In discrepancy judgment, the result of calculation and the set value or logic is compared to make judgment of any discrepancy. If no discrepancy is found, the process does end to repeat the same sequence. If a discrepancy is found, related parameters are corrected at a step of correction and writing to terminate writing in the memory. By repeating this sequence, correction to feed back the discrepancy to subsequent arithmetic operations can be performed.

Here, discrepancy between the result of calculation and the set value or logic means that, for example, logic naturally increases charge state during charging and any discrepancy is found when the charge state is decreased during charging. Similarly the charge state is decreased during discharging, or charge state is not varied under the condition where influence of self-discharge can be ignored during resting. If there is discrepancy, correction is effected. Then, matrixing of such items may be performed to make discrepancy judgments taking the matrix as a discrepancy matrix.

While it is not possible to directly measure the state of the power storage means, the foregoing obvious phenomenon or characteristics are taken as set information to compare with the result of calculation. If a discrepancy is found, the value of the storage means and the input of the arithmetic means are corrected with learning.

By this, it becomes possible to realize the state detection system of the power storage means which is higher accuracy than the characteristic data used in arithmetic operation.

Fig. 3 is a circuit diagram showing an equivalent circuit of the power storage means. In Fig. 3, the reference numeral 201 denotes an electromotive force (OCV), 302 denotes an internal resistor (R), 303 denotes an impedance (Z), 304 denotes a capacitor component (C). There are illustrated a parallel connection pair of the impedance 303 and the capacitor component 304 and a series connection of the internal resistor 302 and the electromotive force 301. When a current I is applied to the power storage means, a voltage (CCV) between the terminals of the power storage means is expressed by an equation (1).

$$CCV = OCV + IR + Vp \quad \text{.....(1)}$$

wherein Vp is polarized voltage, Z and C are voltages of the parallel connection pair.

OCV is used for calculation of SOC or allowable charge and discharge current. In the condition where the power storage means is charged and discharged, it is not possible to directly measure OCV. Therefore, OCV is derived by subtracting IR drop and Vp from CCV as expressed by the following equation (2).

$$OCV = CCV - IR - Vp \quad \text{..... (2)}$$

Fig. 4 is a diagrammatic illustration showing SOC, an allowable charge current and allowable discharge current of the power storage means. Associating with increase of SOC, the allowable discharge current is increased and allowable charge current is decreased. Assuming the maximum allowable voltage of the power storage means is Vmax and minimum allowable voltage is Vmin, the allowable charge current Icmax and allowable discharge current Idmax are respectively expressed by the following equations (3) and (4).

$$Icmax = (Vmax - OCV)/Rz \quad ..... (3)$$

$$Idmax = (OCV - Vmin)/Rz \quad ..... (4)$$

wherein Rz is equivalent impedance of R, Z, C in Fig. 3.

Accordingly, a discrepancy is found in overcharging or over discharging by detection upon charging and discharging at a current smaller than or equal to Icmax and Idmax, the value of Rz is corrected. For example, Rz is increased by 1%.

Fig. 5 is a diagrammatic illustration showing variation of voltage during charging by a pulse current of the power storage means. A curve of CCV shown by a solid line is risen from a charge start timing (A) and abruptly drops at a charge terminating timing (B). Dropping is due to IR drop. Subsequently, CCV is decreased moderately to gradually approach the set information of OCV shown by one-dotted line. A voltage variation in this period mainly corresponds to Vp. On the other hand, the set information of OCV not influenced by the IR drop or Vp is increased from A to B during charging but is not varied during a period between B where a current is 0A to D (under the condition where influence of self-discharge or environmental temperature can be ignored). In contrast to this, the calculated value of OCV shown by the broken line is not consistent with the set information of OCV, and shows a moderately decreasing curve even from B to D.

When the equation (2) is used in calculation of OCV, R can be directly obtained by actually measuring CCV and I and expressed by the following equation (5) using variation amount dCCV and dI in a short period.

$$R = dCCV/dI \quad \text{..... (5)}$$

Therefore, with the present invention, taking the fact that variation of OCV is 0V at 0A as set value, for example, when the calculated value of OCV during this period is varied as shown in Fig. 5, Vp is corrected.

On the other hand, when SOC is derived from OCV, the set value or logic of SOC and the calculated value are also varied as shown in Fig. 5. Even in this case, it becomes possible to detect discrepancy of Vp. Then, after correction of Vp, it is fed back to subsequent calculation.

The table 1 shows a relationship between variation of SOC of the present invention and correction amount of Vp. With taking a time scale as t, and taking a timing where the current value becomes 0A as t = 0, the correction amount of Vp is determined from variation of SOC at $t < 0$ and variation of SOC at $t > 0$. For example, if variation of SOC at $t < 0$ is increased and variation of SOC at $t > 0$ is also increased, Vp is decreased by 1%.

TABLE 1

SOC Variation (t<0)	SOC Variation (t>0, Current OA)	Vp Correction
Increase	Increase	-1%
Increase	Decrease	+1%
Decrease	Increase	+1%
Decrease	Decrease	-1%

Then, these calculations are repeated for a plurality of times. By this, Vp gradually approaches the set value by learning. Namely, Vp is automatically tuned.

While the absolute value of the correction amount is uniform at 1% here, it is preferred that this value is optimized depending upon the power storage means, current pattern of the load, measurement error of the measuring means and so forth. On the other hand, as shown, it is preferred to apply Fuzzy theory for indicating direction of correction.

While state of the power storage means cannot be measured directly similarly to SOC or OCV, according to the present invention, the characteristics or normal phenomenon in the period where the current value is less than or equal to a predetermined value set forth above as set value or logic, the correction amount is derived by Fuzzy theory by comparing the result of calculation per se. This is fed back to the subsequent calculation to repeat learning calculations.

Therefore, whenever a calculation is repeated, precision can be improved. Due to the individual differences of the initial characteristics, environment dependency, secular change and so forth are automatically tuned. Thus, these plurality of parameters and data of correction coefficient can be eliminated.

For example, in the foregoing example, Vp depends on a complicate parameter, such as individual difference or secular change, and further individual difference of secular change and so forth. Upon modeling and reproducing these parameters accurately for taking in calculation, it becomes necessary to obtain the initial characteristics, a plurality of parameters, data to require substantial period and load. However, in the present invention, as influence of these individual differences, secular change and so forth are calculated with learning under actual use environment, these parameters are not required.

Fig. 6 is a constructional illustration of the power source unit according to the present invention. In Fig. 6, the reference numeral 701 denotes a calculation procedure A, 702 denotes a calculation procedure B, 703 denotes a correction amount calculation procedure. The arithmetic means 104 shows a part of the calculation procedure, and the arithmetic means have the arithmetic procedure A and the arithmetic procedure B.

For example, the calculation procedure A 701 is taken as arithmetic procedure of SOC (hereinafter referred to as SOCV) derived from OCV set forth above, and the calculation procedure B 702 is taken as calculation procedure of SOC (hereinafter referred to as SOCi based on a current integration. In calculation of SOCi, the equation (6) is used.

$$SOCi = SOCo + 100 \times d\,I/Q \qquad \ldots\ldots (6)$$

wherein SOCo is an initial value of SOC upon starting of charging and discharging, d I is a various amount of the current integrated value, Q is a maximum charge amount (full capacity). Assuming a charge efficiency of the power storage means as ç, an integrated charge current as Ic and an integrated discharge current as Id, d I is expressed by the following equation (7).

$$d\,I = ç \times Ic - Id \qquad \ldots\ldots (7)$$

SOCi is superior in indicating variation amount in a short period, namely response characteristics, for directly calculating the current. However, an absolute value is not always correct due to individual differences or secular change of Q, influence of ç or erroneous accumulation of current integrator.

On the other hand, SOCV can be calculated by the absolute value with high precision by learning. However, as this takes a little period in learning, response characteristics are relatively low in comparison with SOCi. Therefore, by the correction amount calculation procedure 703, variation of SOCV and SOCi in relatively long period is compared to derive the correction amount to correct the item of d I/Q of the equation (6). On the other hand, SOCo is corrected with SOCV at arbitrary timing.

By this, it becomes possible to achieve both response characteristics of SOCi and high precision calculation of

SOCV. On the other hand, the correction amount is derived by comparing the results of calculation per se to feed back the results of calculation for subsequent calculations to repeat learning calculation. Furthermore, since the individual difference of Q, secular change, influence of ç and accumulation of error in the current integrator can be corrected by learning calculation based on SOCV, these correction parameters are not required. Accordingly, it becomes possible to eliminate significant periods and loads spent for obtaining these parameters or data.

In addition, as the calculation procedure A 701, similar effects can be obtained using SOC calculated from the resistance of the power storage means or SOC calculated from electrolyte concentration.

Fig. 7 is a diagrammatic illustration showing a relationship between OCV and SOC of the power storage means. Associating with increase of SOC, OCV is increased gradually. Such relationship of SOC and OCV is shown in many power storage means, such as lithium secondary battery, electric double layer capacitor and so forth.

Using the characteristics of the power storage means of Fig. 7, the maximum charge amount (full capacity) Q can be derived. For example, assuming that two different charge states are SOC1 and SOC2, residual capacity corresponding to these are Q1 and Q2 and current integrated value there between is dQ (= d I), the following equations (8) to (11) are established:

$$SOC1 = 100 \times Q1/Q \qquad \text{..... (8)}$$

$$SOC2 = 100 \times Q2/Q \qquad \text{..... (9)}$$

$$SOC1 - SOC2 = 100 \times (Q1 - Q2)/Q$$

$$= 100 \times dQ/Q \qquad \text{..... (10)}$$

$$Q = 100 \times dQ/(SOC1 - SOC2) \qquad \text{..... (11)}$$

Thus, full capacity Q of the power storage means can be derived. Similarly, full capacity Q can be derived using SOC derived from the electrolyte concentration or internal resistor and the current integration value.

Then, by feeding back Q thus derived to the equation (6), influences of individual differences of Q and secular change can be corrected to permit further precise state detection. Correction parameters of the individual differences and secular change becomes unnecessary to eliminate significant time and load required for obtaining parameters and data.

Table 2 is a table showing a relationship of the correction coefficient K of the full capacity Q relative to the initial capacity Q0 of the power storage means. In this embodiment, a ratio between the initial capacity of the power storage means stored in the storage means and the full capacity Q derived from the equation (11) is derived to obtain a correction coefficient K depending thereon.

TABLE 2

Q/Qo	1.0	0.9	0.8	0.7	0.6	0.5
K	1.0	0.81	0.64	0.49	0.36	0.25

In general, the power storage means decreases the full capacity associated with secular change. At the same time, the internal resistance is increased. A continuous charge and discharge period derived from the residual capacity, allowable charge current and allowable discharge current derived from equations (3) and (4) and allowable heat generation amount (or cooling control) or allowable charge and discharge power and so forth have to be corrected, the initial values depending upon secular change. The foregoing correct coefficient is used for correction of these. Then, these values are preferably optimized depending upon the kind or system of the power storage means.

As set forth above, with the present invention, influences of individual differences or secular change of the continuous charge and discharge period, allowable charge current and allowable discharge current and allowable heat generation amount (or cooling control) or allowable charge and discharge power and so forth is corrected to permit more precise state detection. On the other hand, these correction parameters become unnecessary. Accordingly, it becomes possible to eliminate significant period and load spent for obtaining these parameters or data.

Fig. 8 is a constructional illustration of a photovoltaic generation equipment, to which the state detection system and the power source unit according to the present invention is applied. In Fig. 8, the reference numeral 1001 denotes a commercial power source, 1002 denotes a photovoltaic generation equipment, 1003 denotes a load device, 1004 denotes a control converter, 1005 denotes a switch, 1006 denotes a state detecting device and 1007 denotes a power source unit.

The state detecting device 1006 is constructed with the measuring means 102, the storage means 103, the arithmetic means 104, the communication means 105, the first correction means 106 and the second correction means 107. On the other hand, the power source unit 1007 is constructed with a series connected circuit with a plurality of power storage means 101 connected in series, and the state detecting device 1006.

Both ends of the series connected circuit of the power storage means 101 is connected to the control converter 1004. The control converter 1004 is further connected to the commercial power source 1001, the photovoltaic generation equipment 1002 and the load device 1003 via the switches 1005 respectively. On the other hand, by a control of a main control unit (MCU) of the control converter 1004, the commercial power source 1001, the photovoltaic generation equipment 1002, the load device 1003 are switched by the switches 1005. Also, a command from the state detection device 1005 is connected by bidirectional communication between the communication means 105 and the MCU.

The photovoltaic generation equipment converts sun light into a direct current by solar cells and outputs an alternating current power by an inverter device. On the other hand, the load device 1003 is household electric equipment, such as an air conditioner, a refrigerator, an electronic oven, lighting and so forth, an electric equipment, such as a motor, an elevator, a computer, a medical equipment and so forth, or a secondary power source unit. Then, the control converter 1004 is a charge and discharge device which converts the alternating current power into the direct current power or converts the direct current power into the alternating current power, and also serves as a controller for controlling charge and discharge and controlling the equipment, such as the photovoltaic generation equipment 1002, the load device 1003 and so forth.

Here, this equipment may incorporate the switch 1005 therein. On the other hand, the power source unit according to the present invention may take connections other than those illustrated herein. With the shown embodiments, when sufficient power required by the load device 1003 cannot be supplied from the commercial power source 1001 or the photovoltaic generation equipment 1002, the power is supplied from the power storage means 101 via the control converter 1004. On the other hand, when power supply from the commercial power source 1001 or the photovoltaic generation equipment 1002 becomes excessive, the excessive power is stored in the power storage means 101 via the control converter 1004.

During these operations, the state detecting device 1007 may detect state of the power storage means 101 by each of the first to the sixth embodiments or the combination thereof. For combination of these, syllogism is applied. On the other hand, the result of state detection is fed to the control converter 1004 as a control amount for state or allowable charge and discharge current and so forth of the power storage means 101. The control converter 1004 controls charging and discharging depending thereon. Particularly, since the state detection device 1007 can perform high precision state detection, the power storage means 101 can be used safely and effectively.

On the other hand, in the embodiment shown, it becomes possible to lower contract demand or power consumption of the commercial power source 1001 and to lower rated power to be generated by the photovoltaic generation equipment 1002 to permit reduction of investment or running cost. When power consumption is concentrated to a certain time zone, the power is supplied to the commercial power source 1001 from the power source unit. During a time where power consumption is small, power is accumulated in the power source unit to absorb concentration of power consumption and to equalize power consumption.

Furthermore, the control converter 1004 monitors power consumption of the load device 1003 and controls the load device 1003. Therefore, power saving and effective use of the power can be achieved. As set forth above, with the shown embodiment, the state detection method, the state detection system of the power storage means in high precision and with smaller number of characteristic data to be used for calculation, and the power source unit, distribution type power storage device employing the same can be realized.

Fig. 9 is a constructional illustration showing an embodiment of an electric vehicle, to which the state detection system and the power source unit according to the present invention is applied. In Fig. 9, the reference numeral 1101 denotes a motor generator, 1102 denotes a direct current load device. The motor generator 1101 is connected to the series connected circuit of a plurality of power storage means 101 via the control converter 1004. The motor generator 1101 is directly coupled with a wheel in case of the electric vehicle. In case of a hybrid electric vehicle, an internal combustion engine is further coupled for assisting start-up or driving force (power running) and generation (re-generation). During power running, power is supplied from the power source unit 1007 to the motor generator 1101. During re-generation, power is supplied from the power generator 1101 to the power source unit 1007.

On the other hand, the direct current load device 1102 is an electric load, such as electromagnetic value, audio unit and so forth, or the secondary power source unit. The direct current load device 1102 is connected to the series connected circuit of the power storage means via the switch 1005.

Even in the shown embodiment, the state detection device 1007 may employ respective of the first to sixth embodiment or combination thereof. Via the communication means, state of the power storage means 101 or control amount of the allowable charge and discharge current or the like is fed to the control converter 1004 so that the control converter 1004 may control charging and discharging depending thereon. Particularly, since the state detection device 1007 may perform state detection with high precision, the power storage means 101 may be used safely and effectively.

By this, the hybrid electric vehicle which can assist to a torque of the internal combustion engine upon star-running and can accumulate kinetic energy by converting into electric power, can be realized.

More particularly, the state detecting system according to the present invention comprises a measuring means for measuring one or more of voltage, current, temperature, resistance and electrolyte concentration of a power storage means, a storage means for storing at least one of characteristic data of the power storage means, calculation coefficient and calculation procedure and preliminarily set value to be considered as true value or set information to be a logic considered as true phenomenon, an arithmetic means for calculating state of the power storage means on the basis of the measured value of the measuring means and the set information of the storage means and calculating a correction amount by comparing the calculation result and the set information, and communication means for communicating the calculation result of the arithmetic means to other device, and a correcting means for correcting the value of the storage means or input of the arithmetic means. By this, correction can be performed by comparing the calculation result and set information and feeding back the difference to subsequent calculation. Therefore, the state detection system which can detect state of power storage means achieving high accuracy with less accurate characteristic data is realized.

The correction means according to the present invention may determine a correction amount based on discrepancy of the calculation result of the calculation means and set information. For example, it is natural that charge state increases during charging. If a discrepancy occurs in that the charge state decreases during charging, this is corrected. In addition, it is natural when charge and discharge is performed within the allowable charge and discharge current value capable of charging and discharging the power storage within allowable use voltage range. Thus, overcharging or over discharging is not detected. If overcharging or over discharging is detected, allowable charge and discharge current is corrected. As set forth, according to the present invention, normal characteristics or natural phenomenon is taken as set information and compares with the calculation result to correct the value of the storage means or input of the arithmetic means is corrected with learning.

On the other hand, in the present invention, the value of the measuring means, calculation result or calculation procedure of the arithmetic means, when the current value is smaller than or equal to the predetermined value, the correction value may be the current value. For example, under a condition where influence of self-discharge is small and if current value is 0A, charge state varies little. Namely, when current value is 0A, variation amount of charge state being 0 is taken as set value as true value. If current value is 0A, charge state is varied; correction is performed to feed back the variation amount to the subsequent calculation with learning.

The storage means of the present invention has two or more mutually different calculation procedures. The arithmetic means can derive the correction value from the calculation results of the calculation procedures to perform correction for feeding back the correction value to the subsequent calculation with learning.

On the other hand, the arithmetic means has the charge state calculating means and current integration means of the power storage means to calculate capacity of the power storage means based on two different charge states and current integration value during the period. In this case, the storage means stores the initial capacity of the power storage means, and correction means may determine the correction information based on the capacity and initial capacity of the power storage means.

With the present invention, by performing correction with feeding back the correction information obtained by predetermined arithmetic operation for the subsequent calculation and storage information for calculation, it becomes possible to provide the state detection system which can detect state, such as state of charge or state of health of the power storage means with high precision even when the precision of characteristic data used for calculation is small.

Correction is performed by comparing the calculation result with the set information, such as set value or logic of the calculation result feed back to the subsequent calculation. Therefore, the state detecting system detecting state information of the power storage means with high precision with less precise characteristic data used for calculation with using simple arithmetic expressions, can be realized.

CLAIMS

1. A state detecting system for an electric storage device comprising:

a memory medium storing storage information which includes characteristic data of an electric storage device, calculation information required for performing a calculation for detection of a state of the electric storage device, and set information on a true set value or true logic based on a characteristic of the electric storage device or a phenomenon caused therein;

a calculator which performs the calculation for detection of the state of the electric storage device on the basis of measured information obtained from a measuring instrument for measuring a parameter of the electric storage device required for detection of the state thereof and input information including the storage information and outputs correction information corresponding to the input information when a discrepancy is found in state detection information obtained by the calculation as a result of comparison of the state detection information and the set information; and

a corrector correcting the input information on the basis of the correction information; wherein

the correction information includes internal resistance information of the power storage device,

the calculator outputs correction information corresponding to at least the internal resistance information when the discrepancy is found, and the corrector corrects the internal resistance information on the basis of the correction information corresponding thereto.

2. A state detecting system for an electric storage device according to claim 1, wherein the corrector rewrites the internal resistance information stored in the storage medium on the basis of the correction information of the internal resistance information.

3. A state detecting system for an electric storage device according to claim 1, wherein the calculator judges a discrepancy to be caused and outputs the correction information corresponding to the internal resistance, when detection information of overcharging or overdischarging is obtained in a state where a charging or discharging current in the power storage device is an allowable charging or discharging current or less.

4. A state detecting system for an electric storage device according to claim 1, wherein the input information further includes polarized voltage information of the electric storage device, the calculator further outputs correction information corresponding to the polarized voltage information when the discrepancy is found, and the corrector corrects the polarized voltage information on the basis of the correction information corresponding thereto.

5. A state detecting system for an electric storage device according to claim 1, wherein the input information further includes capacity information of the electric storage device, the calculator outputs correction information corresponding to the capacity information from results of at least two different calculations, and the corrector corrects the capacity information on the basis of the correction information corresponding thereto.

6. A state detecting system for an electric storage device according to claim 5, wherein the input information further includes polarized voltage information of the electric device, the calculator further outputs correction information corresponding to the polarized voltage information when the discrepancy is found, and the corrector corrects the polarized voltage information on the basis of the correction information corresponding thereto.

7. A state detecting system for an electric storage device according to claim 1, wherein the electric storage device comprises a lithium battery.

8. A power supplying system comprising:

an electric storage device;

a state detection system detecting a state of the electric storage device; and a measuring instrument measuring a parameter of the electric storage device and outputting the measured information to the state detection system, wherein

the state detection system comprises a state detecting system as set forth in claim 1.

9. A power supplying system according to claim 8, wherein the electric storage device comprises a lithium battery.

10. A power storage apparatus comprising:

a control converter to which a commercial power source, a photovoltaic generation device and a load device are connected through their respective switches and then an additional switch;

a controller controlling switching of the switches and operation of the control converter;

an electric storage device connected to the control converter;

a state detecting system detecting a state of the electric storage device;

a measuring instrument measuring a parameter of the electric storage device required for detection of the state of the electric storage device and outputting the measured information to the state detecting system; wherein

the control converter controls power between the electric storage device and each of the commercial power source, the photovoltaic generation device and the load device;

the state detecting system comprises a state detecting system as set forth in claim 1;

the state detecting system and the controller are allowed to communicate with each other; and

the controller controlling operation of the control converter on the basis of information from the state detecting system.

11. An apparatus for an electric vehicle comprising:

a control converter connected to a motor;

a controller controlling operation of the control converter;

an electric storage device connected to the control converter;

a measuring instrument measuring a parameter of the electric storage device required for detection of the state of the electric storage device and outputting the measured information to the state detecting system; wherein

the control converter controlling power between the motor and the electric storage device;

the state detecting system comprises a state detecting system as set forth in claim 1;

the state detecting system and the controller are allowed to communicate with each other; and

the controller controlling operation of the control converter on the basis of information from the state detecting system.

12. An apparatus for an electric vehicle according to claim 11, wherein the electric storage device comprises a lithium battery.

13. An apparatus for a hybrid vehicle comprising:

a motor constituting a driving source of a wheel in combination with an internal combustion engine;

a control converter connected to the motor;

a controller controlling operation of the control converter;

an electric storage device connected to the control converter;

a state detecting system detecting a state of the electric storage device; and

a measuring instrument measuring a parameter of the electric storage device required for detection of the state of the electric storage device and outputting the measured information to the state detecting system;

wherein

the state detecting system comprises a state detecting system as set forth in claim 1;

the state detecting system and the controller are allowed to communicate with each other; and

the controller controlling operation of the control converter on the basis of information from the state detecting system.

14. An apparatus for a hybrid vehicle according to claim 13, wherein the electric storage device comprises a lithium battery.

FIG. 1

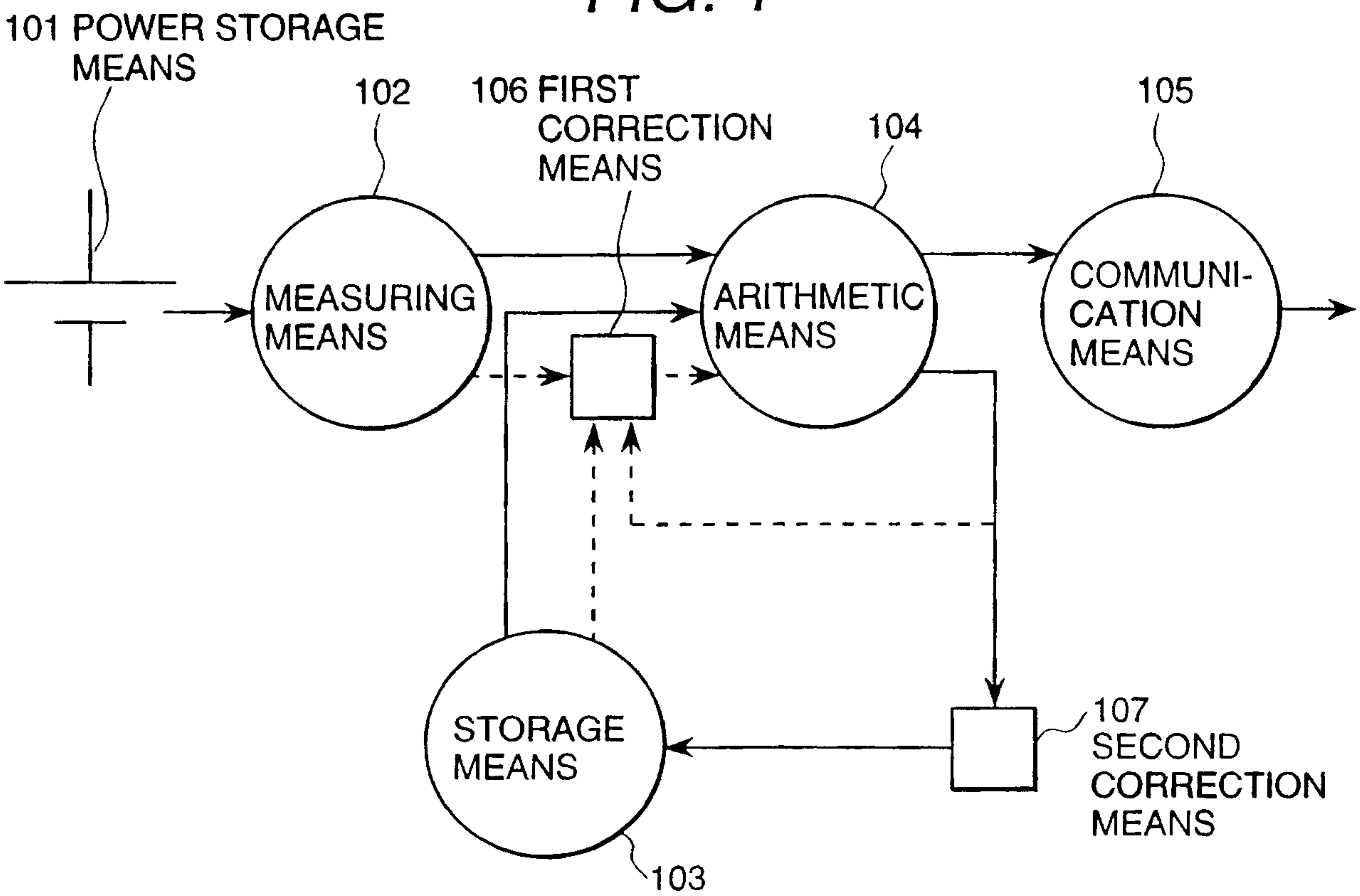
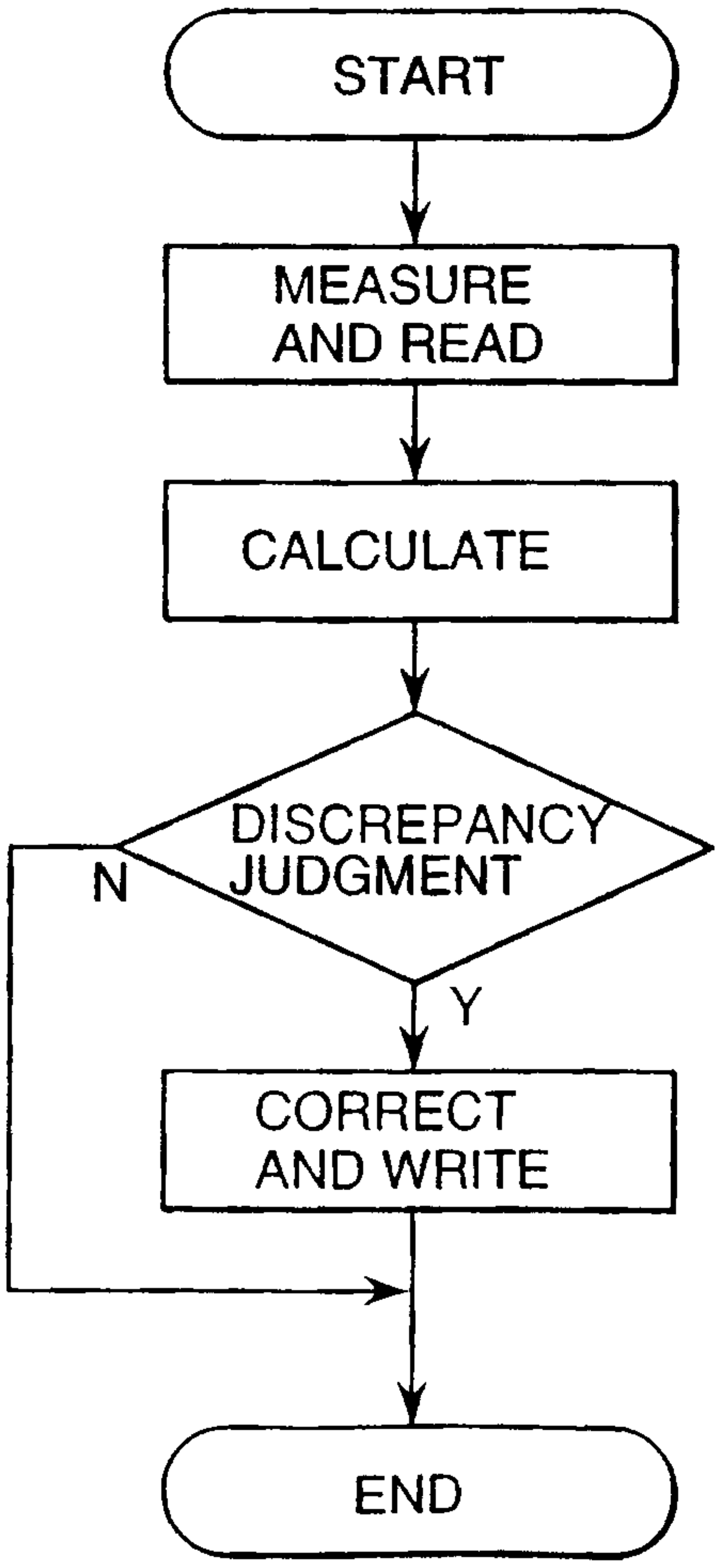


FIG. 2



OPERATION / RESULT	CHARGE	DIS-CHARGE	REST	EQUA-LIZING CHARGE	. . .
SOC	+	−	0	100	
ALLOWABLE CURRENT	Icmax Idmax	←	←	←	
ABNORMAL FLAG	NO	←	←	←	
⋮					

FIG. 3

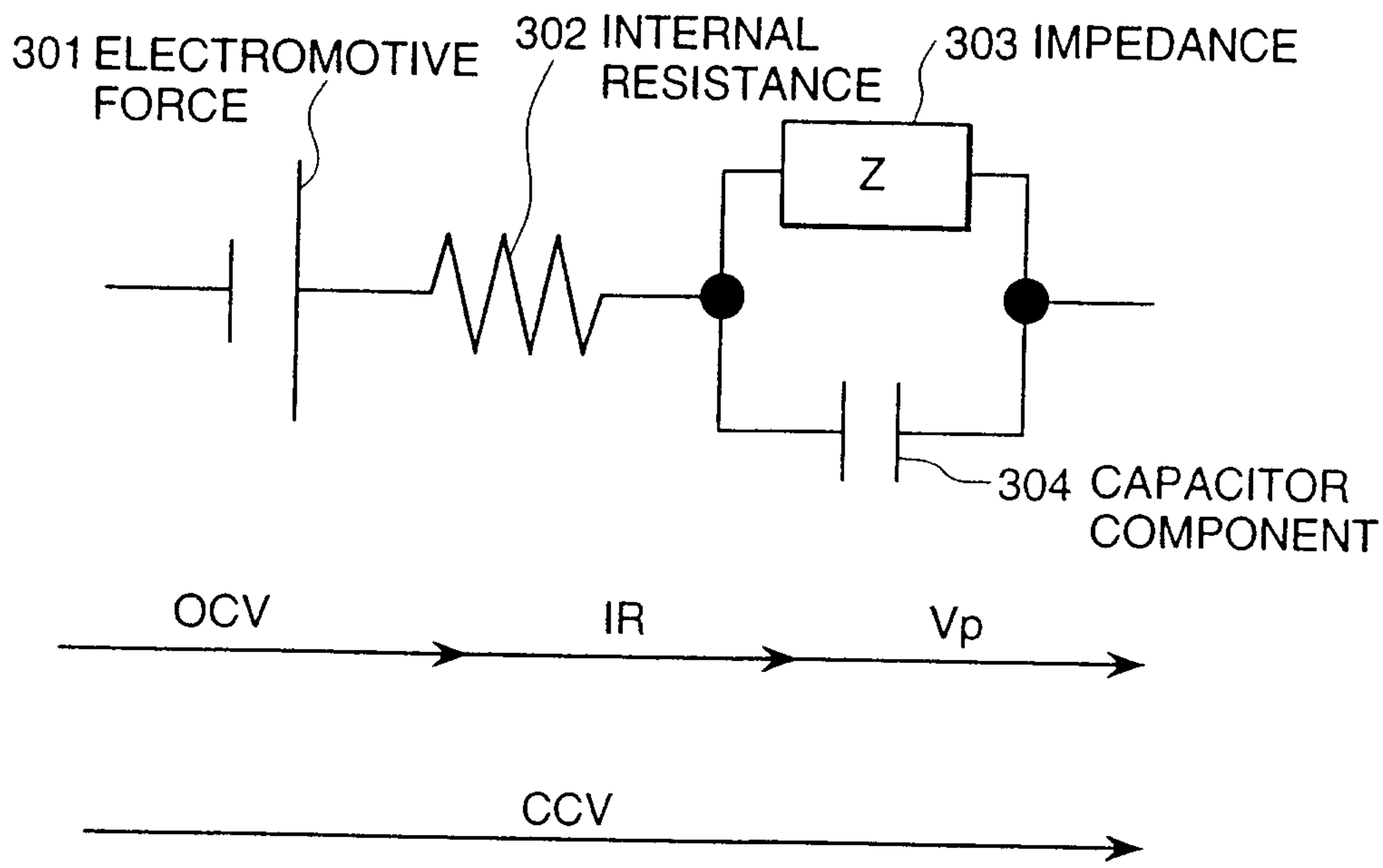

301 ELECTROMOTIVE FORCE
302 INTERNAL RESISTANCE
303 IMPEDANCE
Z
304 CAPACITOR COMPONENT
OCV
IR
Vp
CCV

FIG. 4

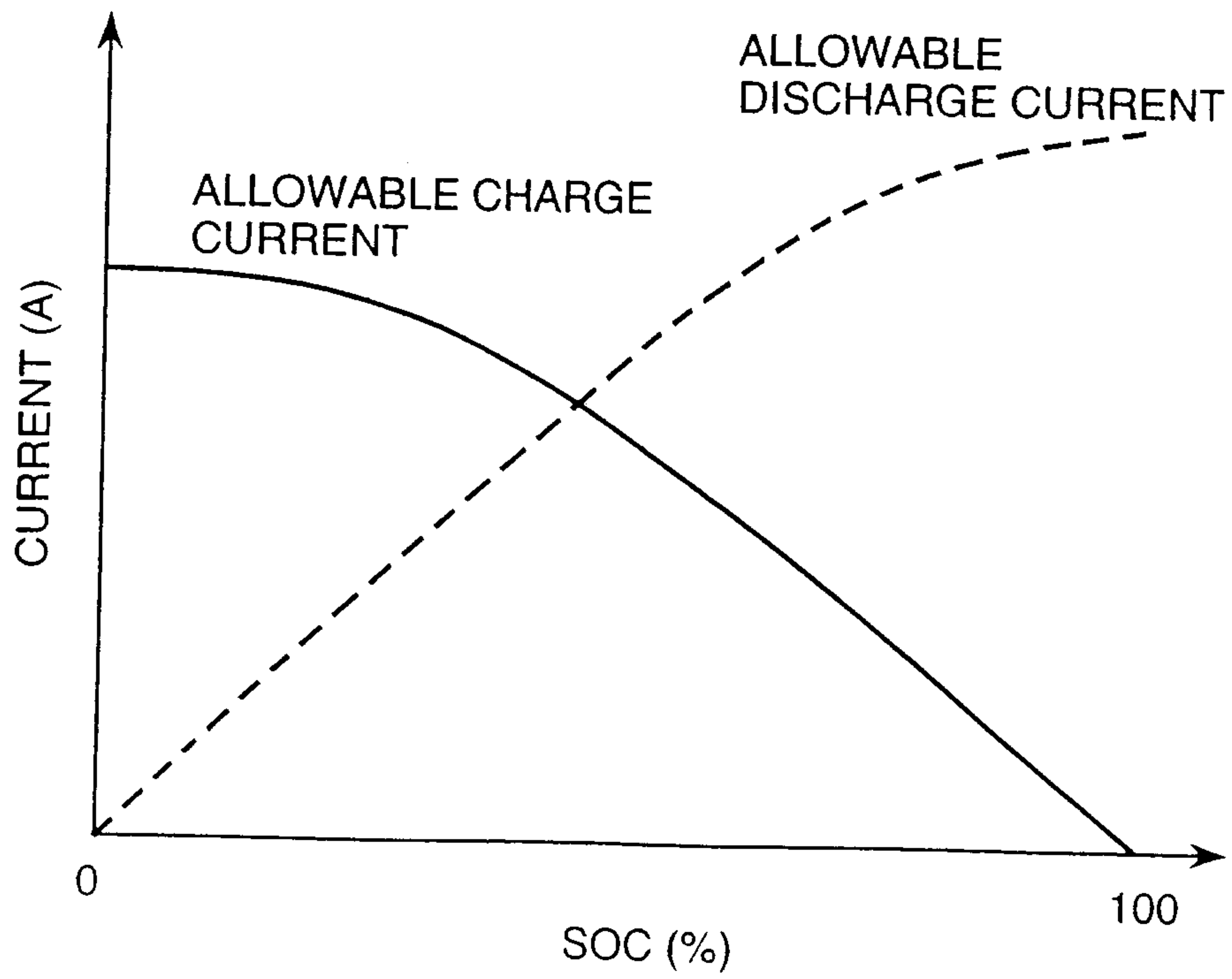

ALLOWABLE DISCHARGE CURRENT
ALLOWABLE CHARGE CURRENT
CURRENT (A)
0
100
SOC (%)

FIG. 5

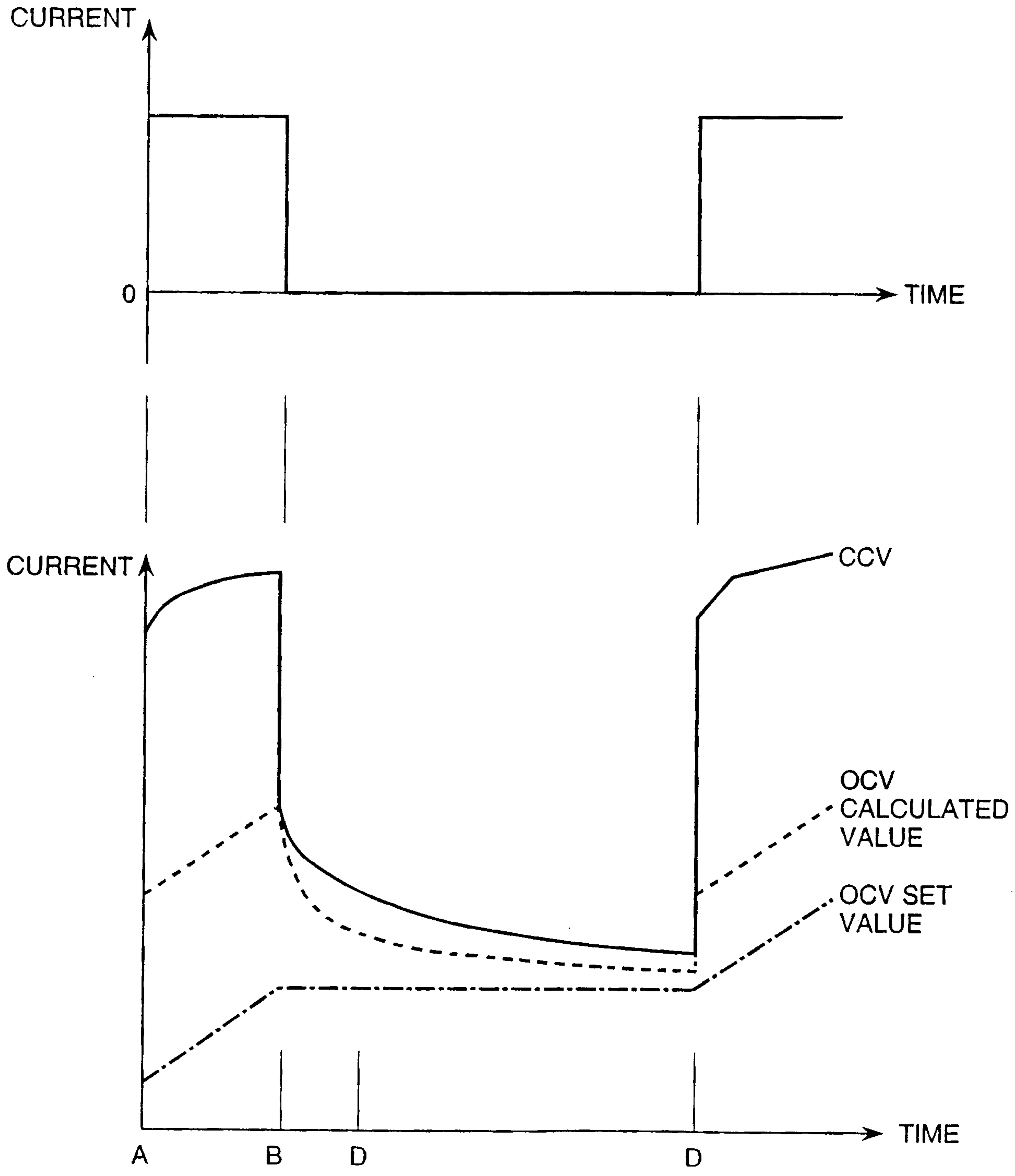

CURRENT
0
TIME
CURRENT
CCV
OCV
CALCULATED
VALUE
OCV SET
VALUE
TIME
A
B
D
D

FIG. 6

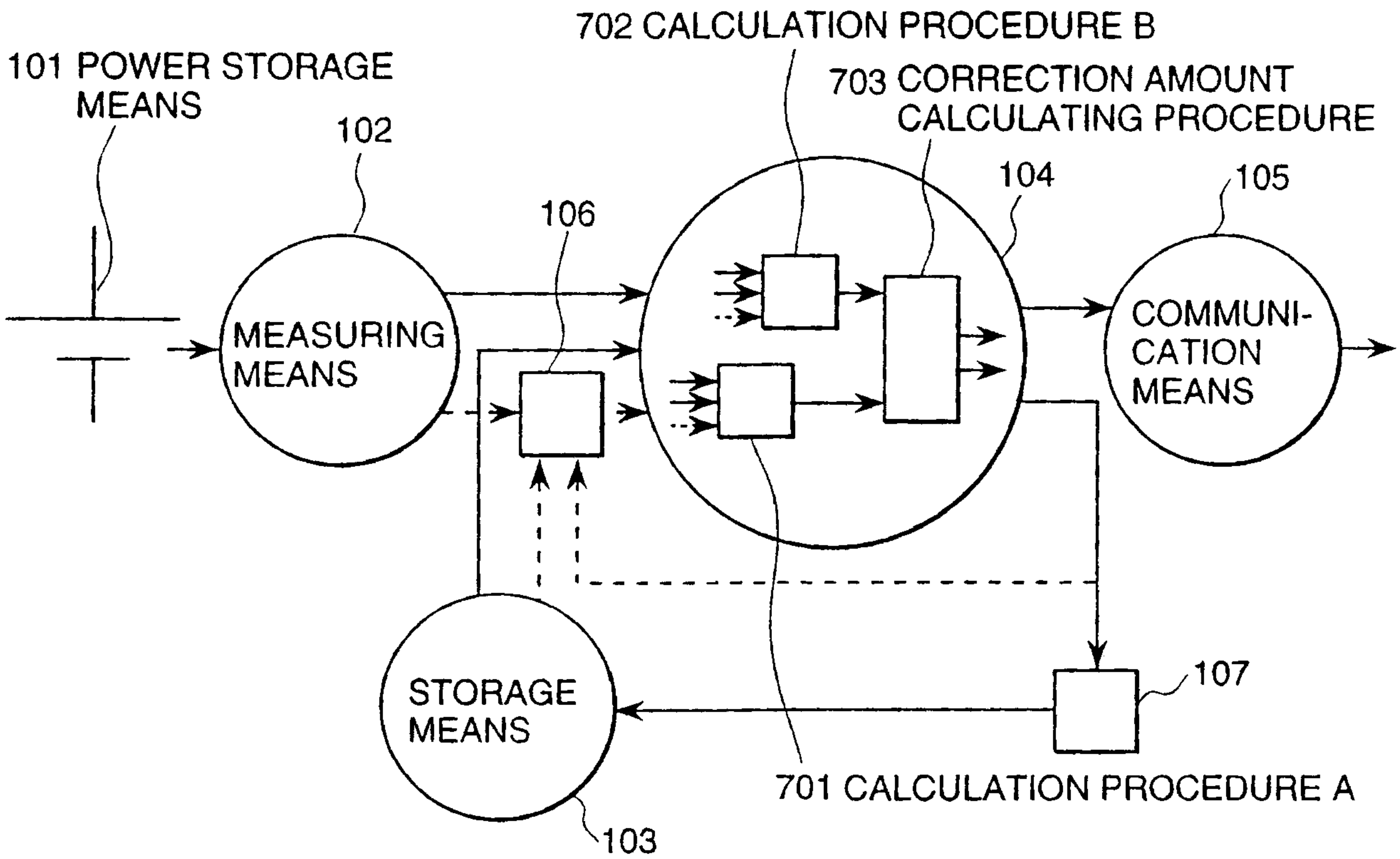

702 CALCULATION PROCEDURE B
101 POWER STORAGE MEANS
703 CORRECTION AMOUNT CALCULATING PROCEDURE
102
104
105
106
MEASURING MEANS
COMMUNI-CATION MEANS
STORAGE MEANS
107
701 CALCULATION PROCEDURE A
103

FIG. 7

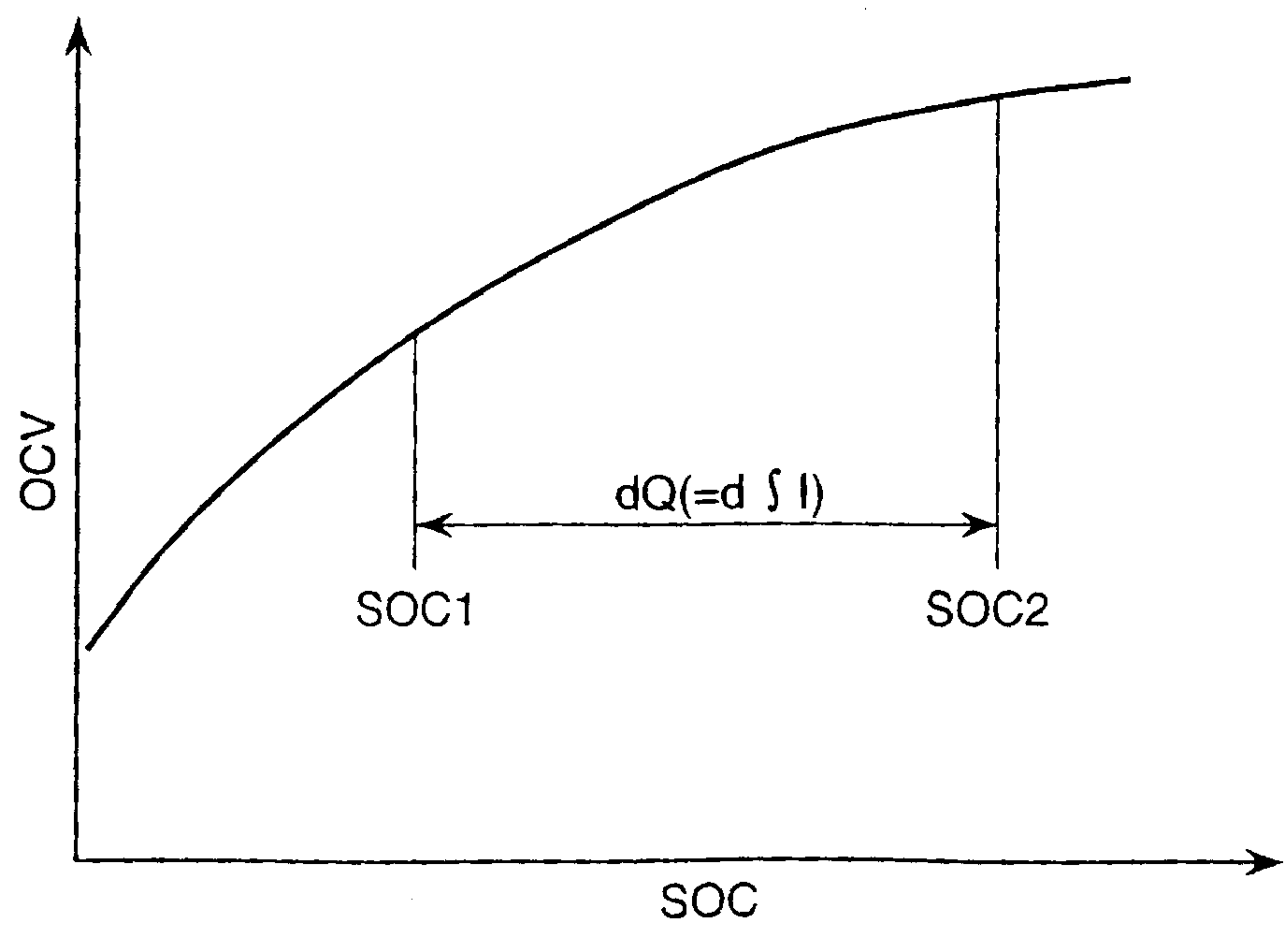

OCV
dQ(=d ∫ I)
SOC1
SOC2
SOC

FIG. 8

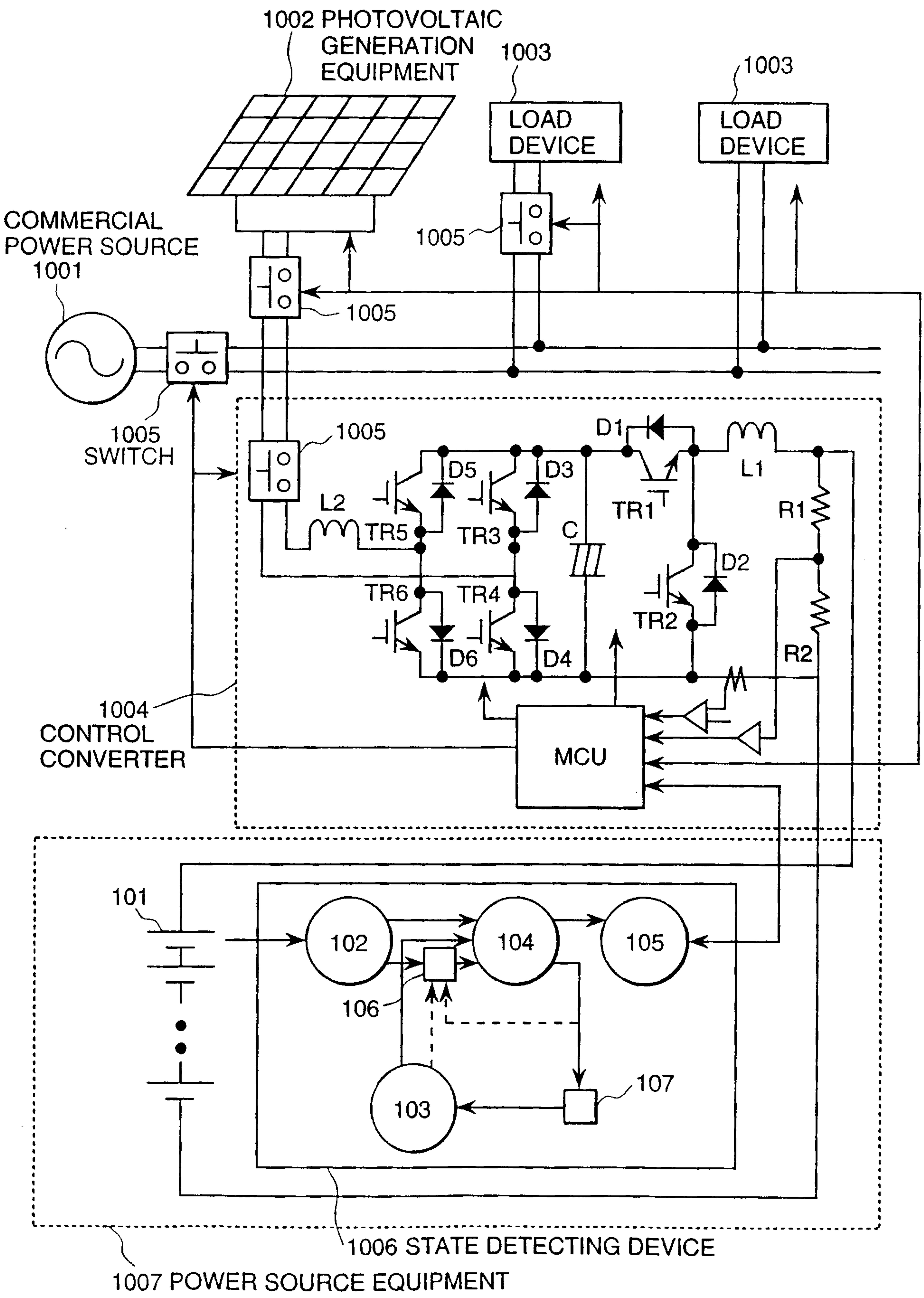

1002 PHOTOVOLTAIC GENERATION EQUIPMENT
1003
LOAD DEVICE
1003
LOAD DEVICE
COMMERCIAL POWER SOURCE 1001
1005
1005
1005 SWITCH
1005
D1
D5
D3
L1
L2
TR5
TR3
TR1
C
R1
D2
TR6
TR4
TR2
D6
D4
R2
1004 CONTROL CONVERTER
MCU
101
102
104
105
106
107
103
1006 STATE DETECTING DEVICE
1007 POWER SOURCE EQUIPMENT

FIG. 9

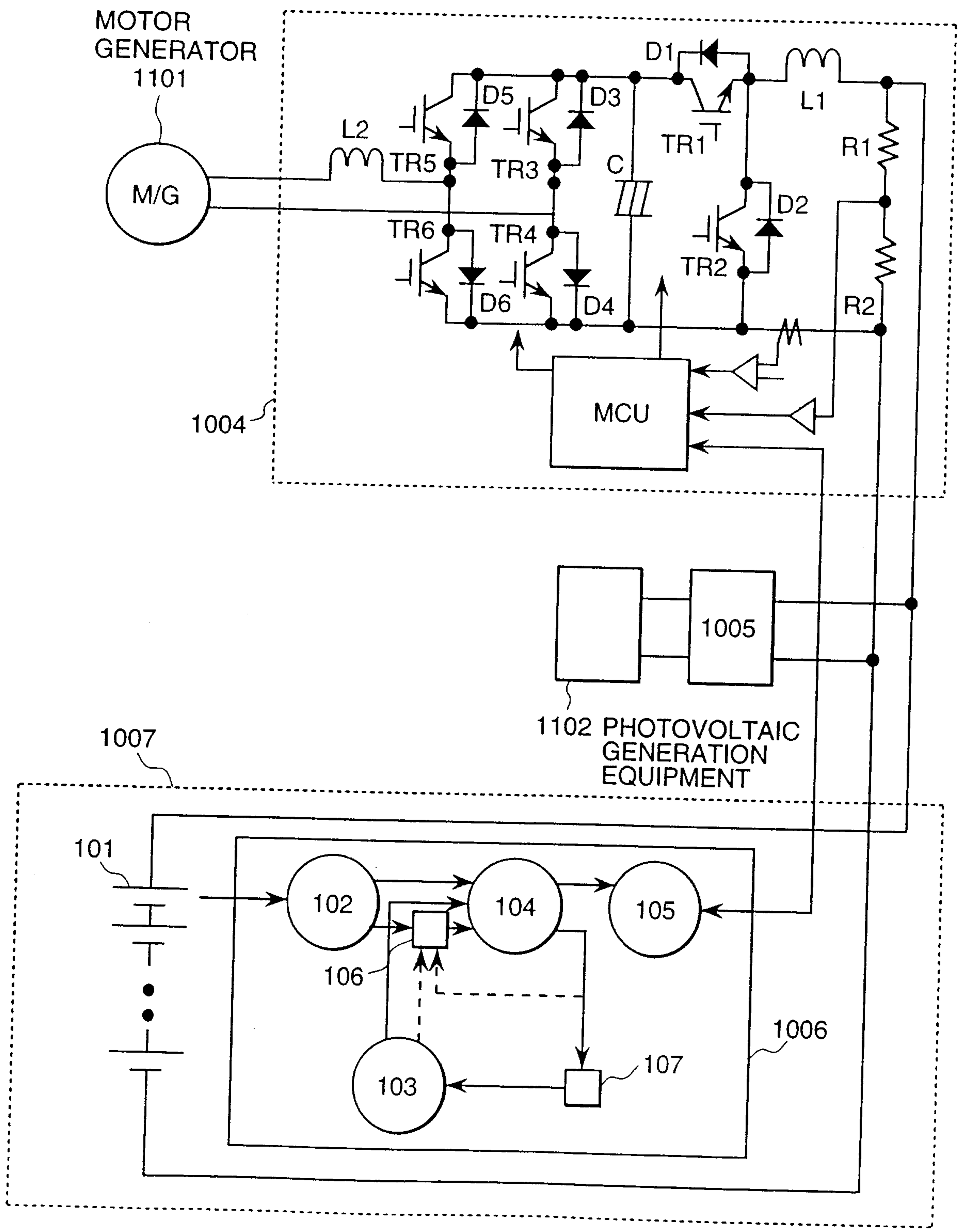
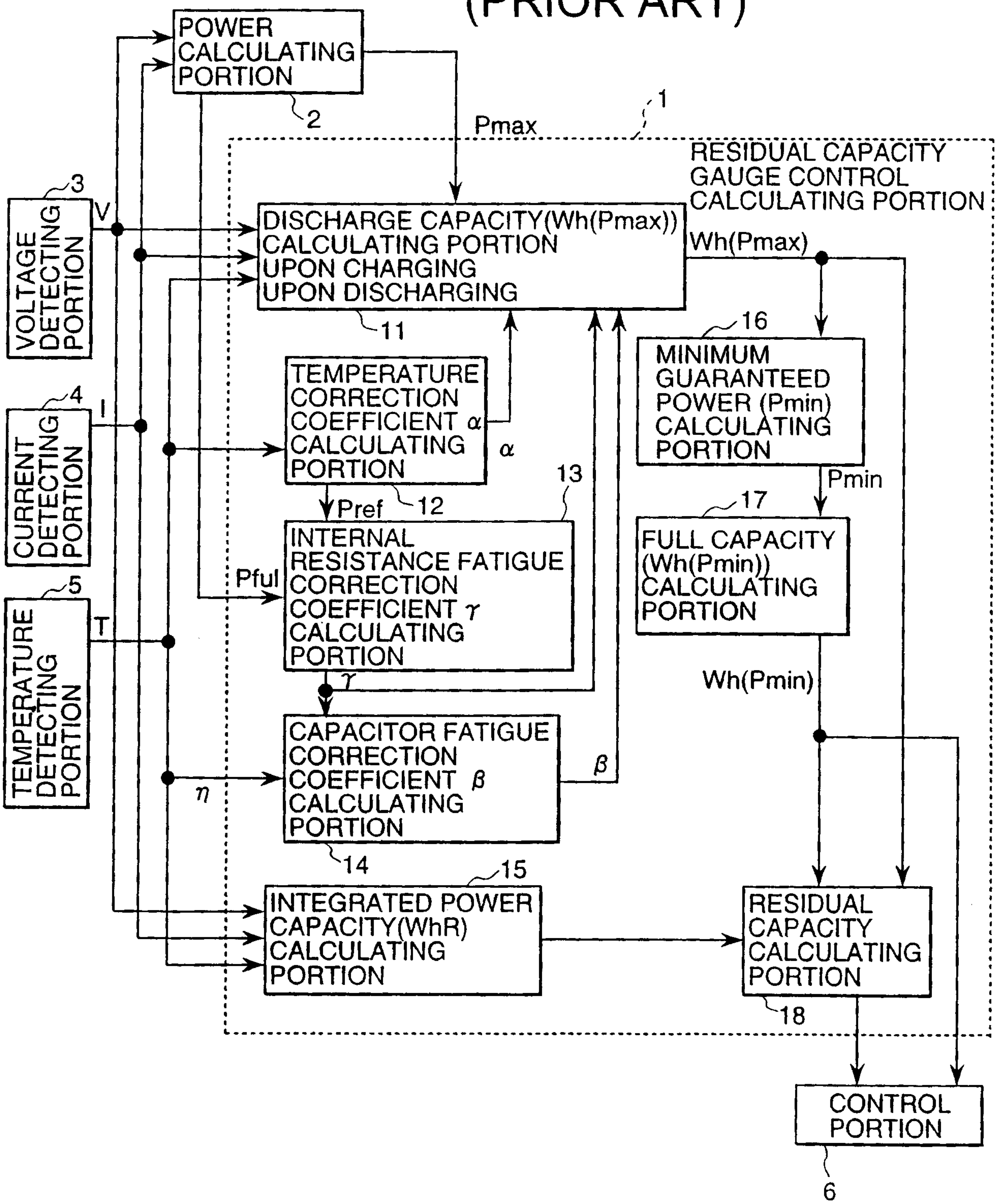
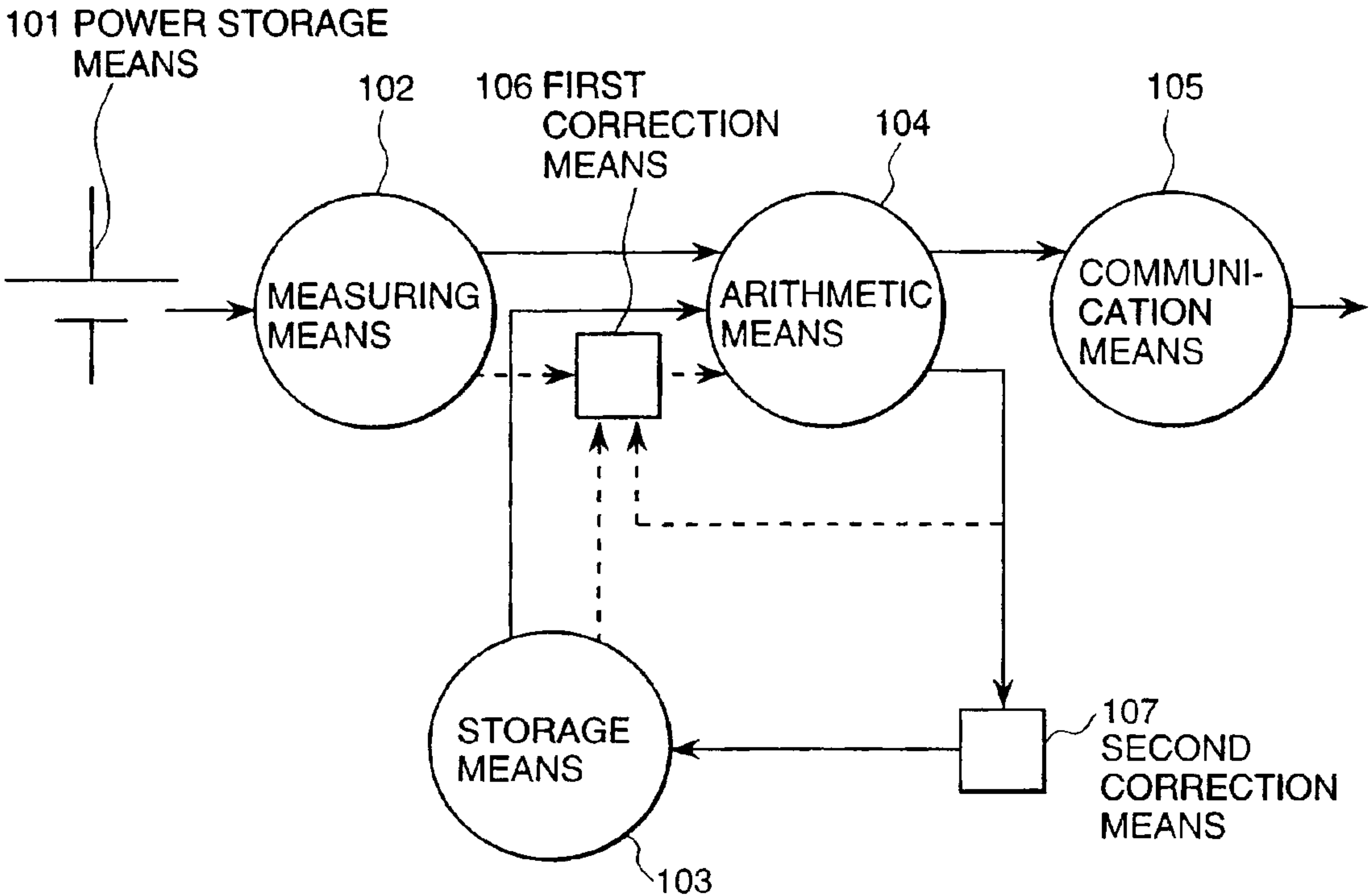

MOTOR
GENERATOR
1101
M/G
L2
TR5
D5
TR3
D3
TR6
TR4
D6
D4
C
D1
TR1
L1
R1
D2
TR2
R2
MCU
1004
1005
1102 PHOTOVOLTAIC
GENERATION
EQUIPMENT
1007
101
102
104
105
106
103
107
1006

FIG. 10
(PRIOR ART)





101 POWER STORAGE MEANS
102
106 FIRST CORRECTION MEANS
104
105
MEASURING MEANS
ARITHMETIC MEANS
COMMUNI-CATION MEANS
STORAGE MEANS
107 SECOND CORRECTION MEANS
103