(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 607 645 A1**

(12) EUROPEAN PATENT APPLICATION

(21) Application number: **93300435.0**

(51) Int. Cl.⁵: **B66B 1/30**

(22) Date of filing: **21.01.93**

(43) Date of publication of application:
27.07.94 Bulletin 94/30

(84) Designated Contracting States:
CH DE FR GB LI

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(54) Regenerative elevator induction motor control.

(57) In a regenerated power consumption circuit wherein power that is regenerated by an elevator induction motor inverter (2) is consumed by a series circuit of a resistor (5) and a switch (6) installed in the inverter DC circuit, a software configuration filter (16A) is installed, whereby the detection signal for when the DC voltage of the DC circuit exceeds the ON-OFF level of the switch is subjected to a filter treatment, and ON-OFF control of the switch is carried out with the maximum switching frequency determined by the time constant of the filter, with respect to variation of the DC voltage. The invention enables the use of a switch with a low switching speed, and in addition, simplifies the circuit configuration for regenerated power consumption.

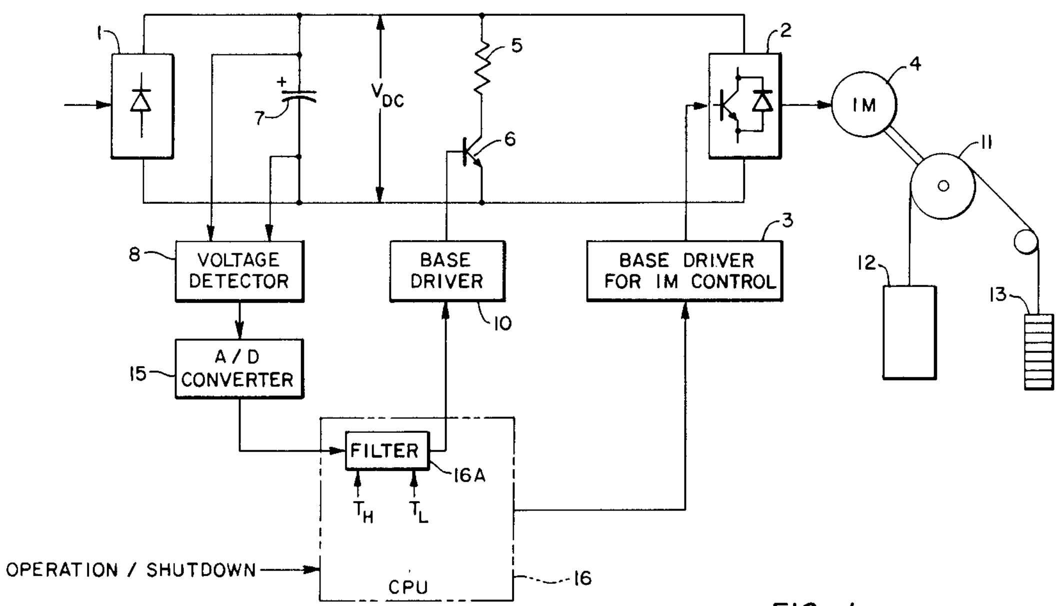

FIG. 1

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This invention relates to a control method for consuming in an inverter the regenerated power from an induction motor that drives an elevator.

When braking is applied during operation of an elevator with an induction motor driven by an inverter, the rotating speed of the motor is higher than the frequency of the inverter, and regenerated power is formed in the motor. As this regenerated power flows into the dc circuit of the inverter, a resistor is set in the dc circuit and it is used to consume (absorb) the regenerated power.

Figure 3 shows the configuration in an example of the conventional regenerated power consumption method. As shown in this figure, the principal circuit of the inverter has converter (1) and inverter circuit (2). The 3-phase ac is converted to dc by converter (1), and it is then converted to 3-phase ac by inverter circuit (2). In this case, control is made by base driver (3) for induction motor control, so that the speed of induction motor (4) can be controlled.

In the conventional power consumption method, a regenerated power consumption circuit composed of resistor (5) and switch (6) formed of semiconductor elements in series is inserted in parallel into the aforementioned principal circuit. On the other hand, the dc voltage on the two ends of principal circuit capacitor (7) is detected by a voltage detector (8). The signal from said voltage detector (8) is input to hysteresis comparator (9). The magnitude of the dc voltage is the basis for ON/OFF control of base driver (10) of said switch (6). In this way, the regenerated power formed in the deceleration of induction motor (4) can be consumed by said resistor (5).

Figure 4 shows the voltage waveform of the principal circuit in the aforementioned operation. As can be seen from this figure, with respect to the dc voltage of the principal circuit, the switch ON level and switch OFF level of said regenerated power consumption switch (6) are set at said comparator (9). As the dc voltage rises in tandem with the regenerated power, the circuit is turned ON, the regenerated power is thus consumed; then as the dc voltage falls, the circuit is turned OFF.

When the conventional regenerated power consumption method is used for an elevator, as shown in Figure 5, the elevator has an induction motor (4) as the power source, and has cage (12) and balance weight (13) loaded on winding drum (11). The velocity pattern for acceleration, deceleration, and constant velocity is generated by a control unit (14), and cage (12) may be stopped at any floor.

The maximum load of the elevator depends on the number of passengers in the cage, etc. As there can be a significant number of passengers, there is a large regenerated power in the case of deceleration.

In addition, the deceleration rate in the case of deceleration depends on the velocity pattern, and the regenerated power varies depending on the passenger number and deceleration rate.

Even in the case of constant velocity operation, when cage (12) is heavier than balance weight (13) due to more passengers, regenerated power is formed when descending. On the other hand, when cage (12) is lighter than balance weight (13), power is regenerated when the elevator ascends. These regenerated power levels also vary as the passenger number changes.

As explained above, the regenerated power of the elevator depends significantly on the passenger number, and the operation status with deceleration or constant velocity. Consequently, for hysteresis comparator (9), the switching frequency and the ON/OFF ratio also depend significantly on the change in the regenerated power. In order to realize reliable operation for switch (6), a switch which allows high-speed switching operation up to several kHz must be used. In addition, it is difficult to design the hysteresis width and ON/OFF operation level of hysteresis comparator (9) and to set the resistance value of resistor (5). Also, the design of the circuit configuration becomes complicated. This is a disadvantage.

The purpose of this invention is to solve the aforementioned problems of the conventional methods by providing a regenerated power consumption method for elevators in which a switch with a low switching speed can be used, and the circuit configuration for the regenerated power consumption can be simplified.

In order to solve the aforementioned problems, this invention provides a regenerated power consumption method in which the regenerated power generated when the elevator is driven with an induction motor is consumed by a serial circuit comprising a resistor and a switch and arranged in a dc circuit of the inverter. In this regenerated power consumption method, there is a software configuration filter which performs filtering treatment of the detected signal as the dc voltage of the aforementioned dc circuit exceeds the ON/OFF level of the aforementioned switch; if the aforementioned dc voltage rises or decreases, the aforementioned switch is ON/OFF controlled by the aforementioned filter.

According to this invention with the aforementioned configuration, when ON/OFF control of the switch is performed as the dc voltage of the inverter crosses the ON level or OFF level of the switch, a filter treatment is performed for the dc voltage of detection. In this way, even when the regenerated power varies, the switching speed of the switch is limited by the frequency determined by the time constant of the aforementioned filter; the switching speed needed by the switch can be set by the time constant of the filter, and any type of switch element can be used. In addition, since the filter has a software configuration, the setting can be changed easily, and the circuit design may be realised by selecting the time constant of the filter and the resistance value.

An embodiment of the invention will now be described by way of example only and with reference to the drawings, in which:

Figure 1 is a schematic diagram showing the configuration of an induction motor control circuit according to this invention.

Figure 2 shows the filter operation waveform in the circuit of Fig. 1.

Figure 3 shows the configuration of a conventional circuit.

Figure 4 shows the voltage waveforms of the conventional circuit of Fig. 3.

Figure 5 shows the configuration of an elevator having an induction motor control circuit.

Figure 1 shows the configuration of an embodiment of this invention. The configuration shown in this figure differs from that shown in Figures 3 and 5 in the following respects: the detected signal of voltage detector (8) is converted to a digital signal by an A/D converter (15). The converted value is filter-treated by a filter (16A) in a control unit (16) which comprises a CPU. The result of the filter treatment is taken as the ON/OFF control signal for base driver (10).

Filter (16A) has a CPU software configuration. With respect to the sampling data of dc voltage V_{dc} of the principal circuit of the inverter, the detected data are modified according to the following formula: (Formula 1)

$$V_{dc}\ (n) = \frac{V_s - V_{dc}\ (n - 1)}{(1 + T/dt)} + V_{dc}\ (n - 1)$$

where,

$V_{dc}(n)$: modified data

V_s: sampled input

$V_{dc}(n - 1)$: data of last round

T: time constant of filter

dt: sampling time interval

That is, suppose the sampling treatment time dt is 10 ms, and the filter time constant T is 30 ms, (1 + T/dt) becomes 4. Now, as 1/4 of the difference between current sample V_S and last-round data $V_{dc}(n - 1)$ is added/subtracted, the modified data $V_{dc}(n)$ is delayed by the time constant T of the filter. Since the modified data $V_{dc}(n)$ with the aforementioned delay is used to control ON/OFF switching of base driver (1), the timing is delayed, and the switching frequency of switch (6) is limited.

For example, when dc voltage V_{dc} of the principal circuit of the inverter rises above the ON line, and a prescribed time has passed after the OFF operation (the filter's time constant), switching is made from OFF to ON, and the switching frequency is decreased. In this case, due to the ON operation of switch (6), the regenerated power is consumed by resistor (5).

On the other hand, switching of filter (16A) from OFF to ON may be carried out in any of the following cases:

(1) When troubles occur, such as insufficient voltage, overvoltage, overcurrent, etc.

(2) When dc voltage V_{dc} drops below the OFF level, and after a prescribed time (filter time constant) from the ON operation.

(3) When a stop command is generated and the inverter is shutoff.

For above items (1) and (3), the operation is realized as controller (16) handles the output frequency and operation state of the inverter and the state of the input sequence.

For the regenerated power consumption operation with the aforementioned configuration, as can be seen in Figure 2 from the filter output waveform with respect to dc voltage V_{dc}, the maximum switching frequency is determined by the times T_H, T_L corresponding to the filter time constant.

As shown in Figure 2, when dc voltage V_{dc} first falls below the OFF level set at filter (16A) (at time t_1) and then exceeds the ON level at time t_2, since the time interval between t_1 and t_2 is shorter than a prescribed time T_H, the output of filter (16A) does not produce an ON operation, and the OFF operation is continued.

When dc voltage V_{dc} exceeds the ON level at time t_3, since the time interval between t_1 and t_3 exceeds the prescribed time T_H, the filter output performs the ON operation.

Similarly, when dc voltage V_{dc} falls below the OFF level at time t_4, since the time interval is shorter than a prescribed time T_L (which may be identical to or different from T_H), there is no OFF operation; the OFF operation takes place at time t_5.

Also, when dc voltage V_{dc} exceeds the ON level at time t_6, as the time interval from t_5 to t_6 is shorter than a prescribed time T_H, there is no ON operation, while the ON operation takes place at time t_8.

Consequently, for filter (16A), the switching output limited by the frequency determined by times T_H, T_L set in the software is generated, and the maximum switching frequency for the regenerated power consumption can be controlled by times T_H, T_L. For example, when times T_H and T_L are set at 30 ms, the maximum switching frequency is 33.33 Hz, and the regenerated power consumption can be performed by using switch (6) with a switching speed appropriate to this frequency.

As described above, the control of the regenerated power consumption is not limited to the case of deceleration of the elevator, it may also be performed corresponding to the variation in the regenerated power generated due to differences in the passenger number and the ascending descending state in the constant speed mode. For the configuration of the equipment, the time constant of the filter can be set appropriately by setting the software, and filter (16A) itself can also be simplified by using the software configuration.

In the aforementioned example, switch (6) and resistor (5) for the regenerated power consumption are arranged as a single circuit. However, it is also acceptable to use a configuration of multiple circuits with a selective switch operation. In this scheme, even in the case when the variation amplitude of the regenerated power is abnormally large and the switching operation of the maximum switching frequency determined by the time constant of filter (16A) is inadequate, the aforementioned multiple circuits can perform ON operation in a parallel way when an overvoltage for dc voltage V_{dc} is predicted; hence, overvoltage can be prevented. On the other hand, when an insufficient voltage is predicted, the insufficient voltage can be prevented by the ON/OFF control of one circuit.

As explained in the above, according to the described embodiment, the regenerated power consumption is performed by detecting the dc voltage of the inverter, with the dc voltage of detection filter-treated by a filter with a software configuration; the maximum switching frequency of the switch is set by the time constant of the filter, the filter time constant is set corresponding to the switching speed of the switch, so as to ensure the regenerated power consumption. In addition, in the circuit design and setting, it is only necessary to change the time constant of the filter, which can be realized by making a simple change in the software. In addition, as far as the circuit configuration is concerned, the conventional hysteresis comparator is not needed, and only the function of the elevator control equipment is used.

Claims

1. A method of consuming regenerated power in an elevator system in which an elevator is driven with an induction motor, the motor being driven from a dc circuit via an inverter, and in which a resistor and a swtich are connected in series to said dc circuit for consuming regenerated power, comprising detecting the voltage in the dc circuit and producing a detection signal, subjecting the detection signal to a filter treatment with a software filter, and ON-OFF controlling the switch with the output of the filter.

2. A method as claimed in claim 1 wherein the detection signal is produced when the dc voltage reaches the ON or OFF level of the switch.

3. A method as claimed in claim 1 or 2 wherein the filter operates to delay the ON-OFF switching of the switch in response to changes in the detected dc voltage.

4. A method as claimed in any preceding claim in which the filter time constant is set in dependence on the number of passengers in the elevator and/or on the motion state of the elevator.

5. A method as claimed in any preceding claim wherein multiple resistor and switch series circuits are connected to the dc circuit and the switches are selectively controlled to provide parallel power consuming circuits.

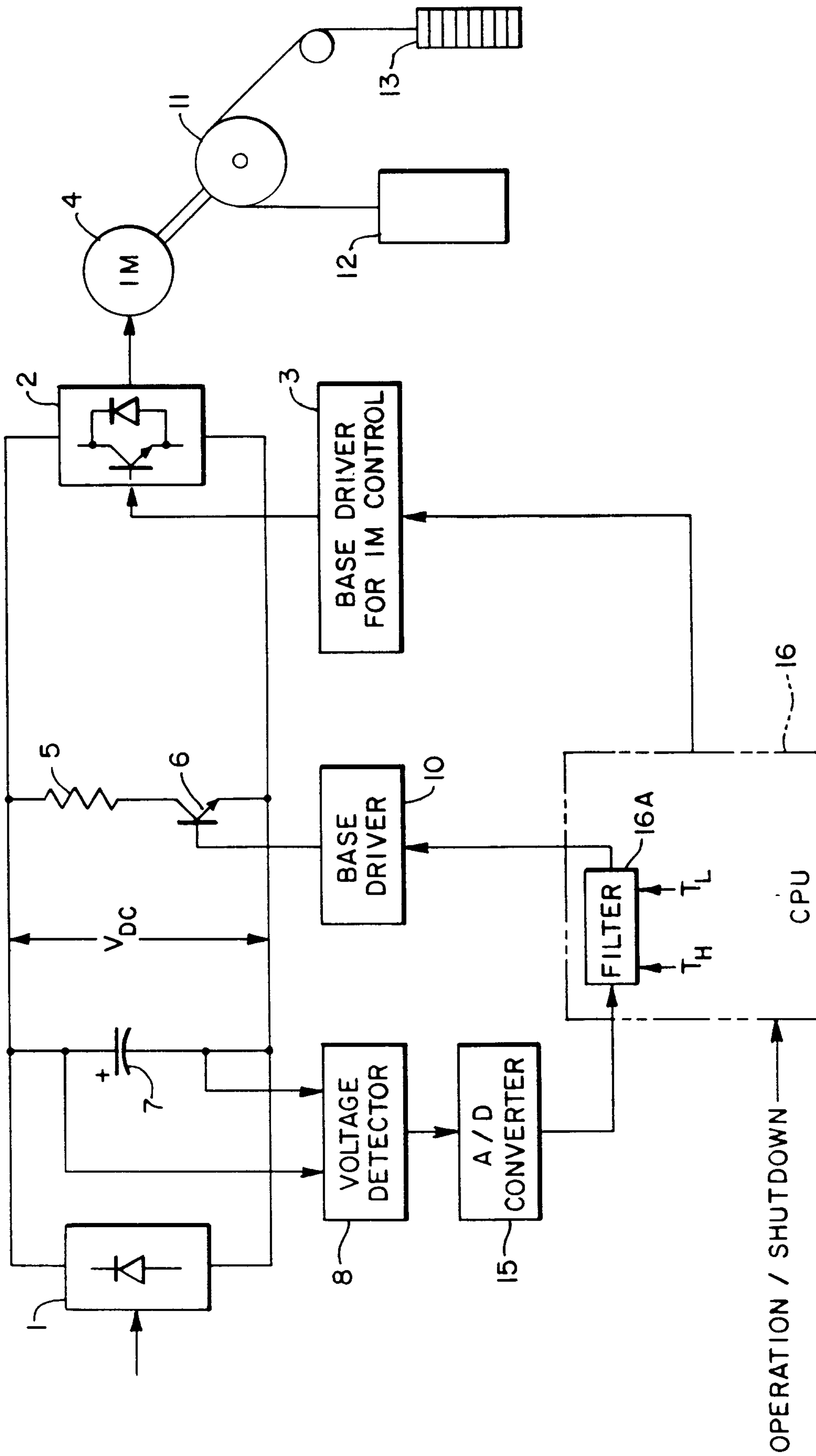
IM
BASE DRIVER FOR IM CONTROL
BASE DRIVER
V_{DC}
FILTER
T_L
T_H
CPU
VOLTAGE DETECTOR
A / D CONVERTER
OPERATION / SHUTDOWN
1
2
3
4
5
6
7
8
10
11
12
13
15
16
16A

FIG. 1

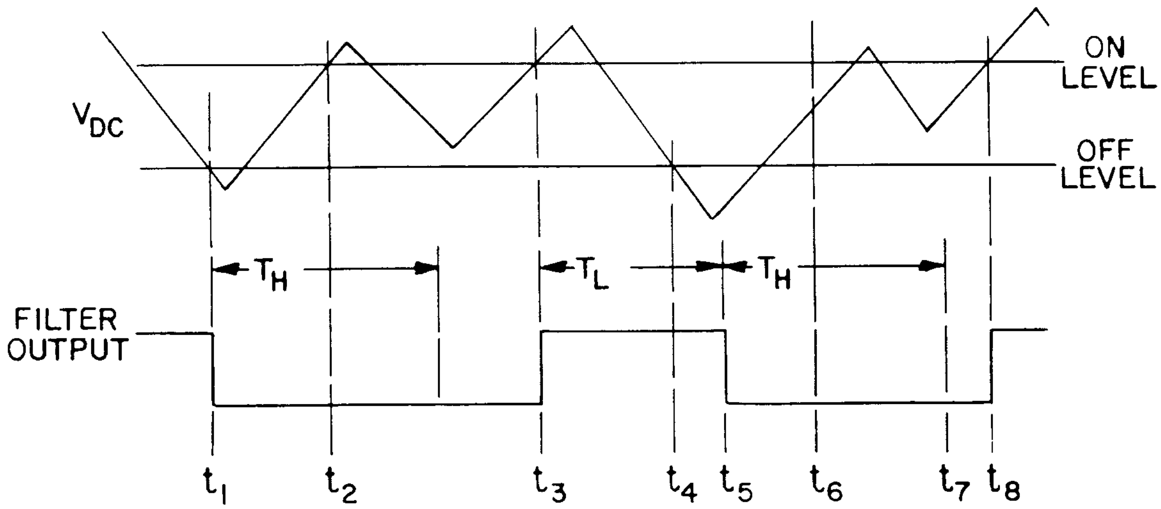
ON
LEVEL
V_{DC}
OFF
LEVEL
T_H
T_L
T_H
FILTER
OUTPUT
t_1
t_2
t_3
t_4
t_5
t_6
t_7
t_8

FIG. 2

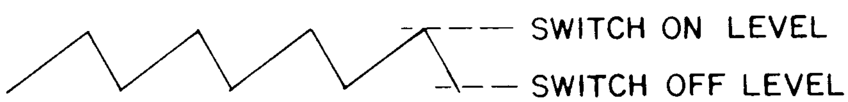
SWITCH ON LEVEL
SWITCH OFF LEVEL

FIG. 4

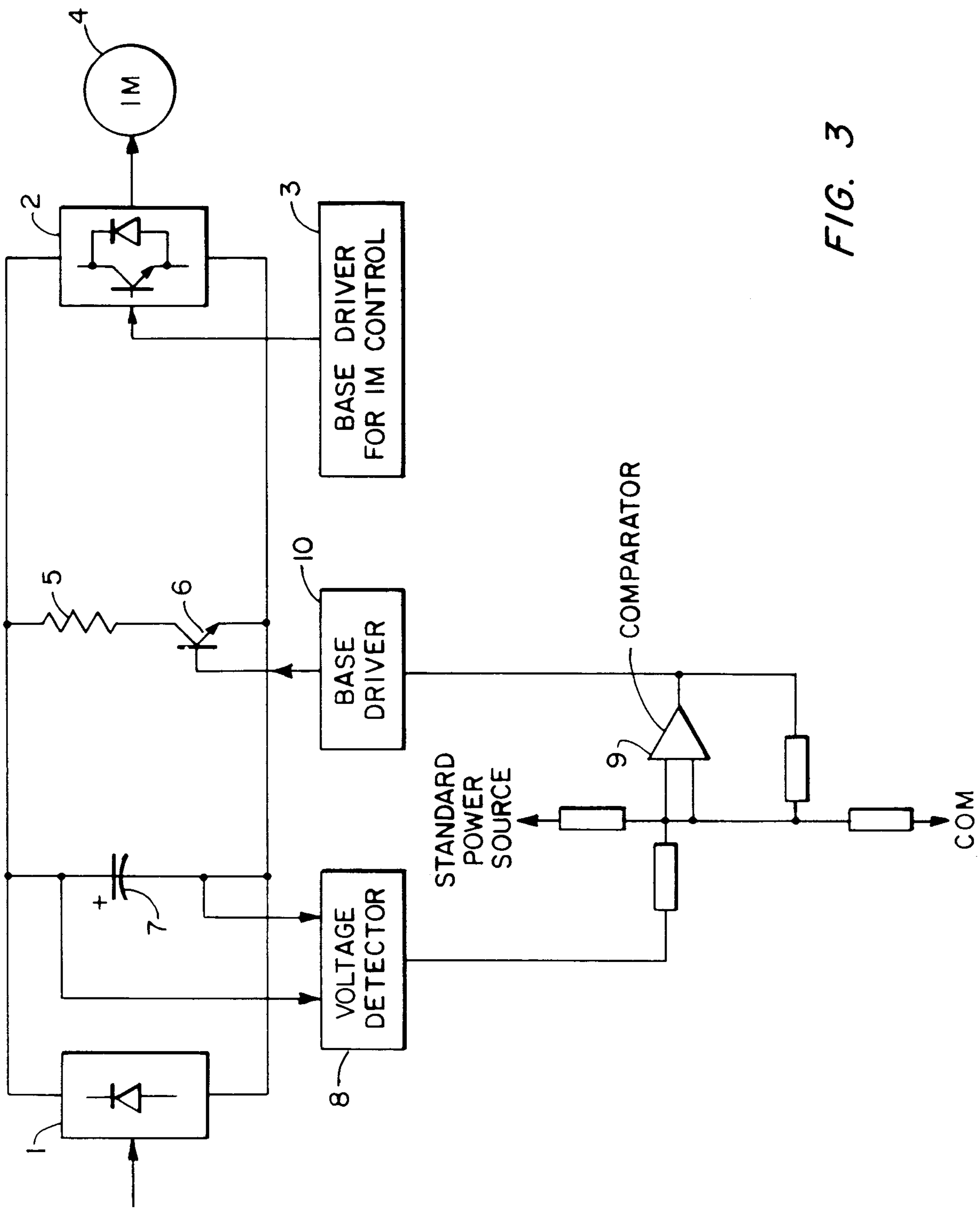
IM
BASE DRIVER FOR IM CONTROL
BASE DRIVER
COMPARATOR
STANDARD POWER SOURCE
VOLTAGE DETECTOR
COM
1
2
3
4
5
6
7
8
9
10

FIG. 3

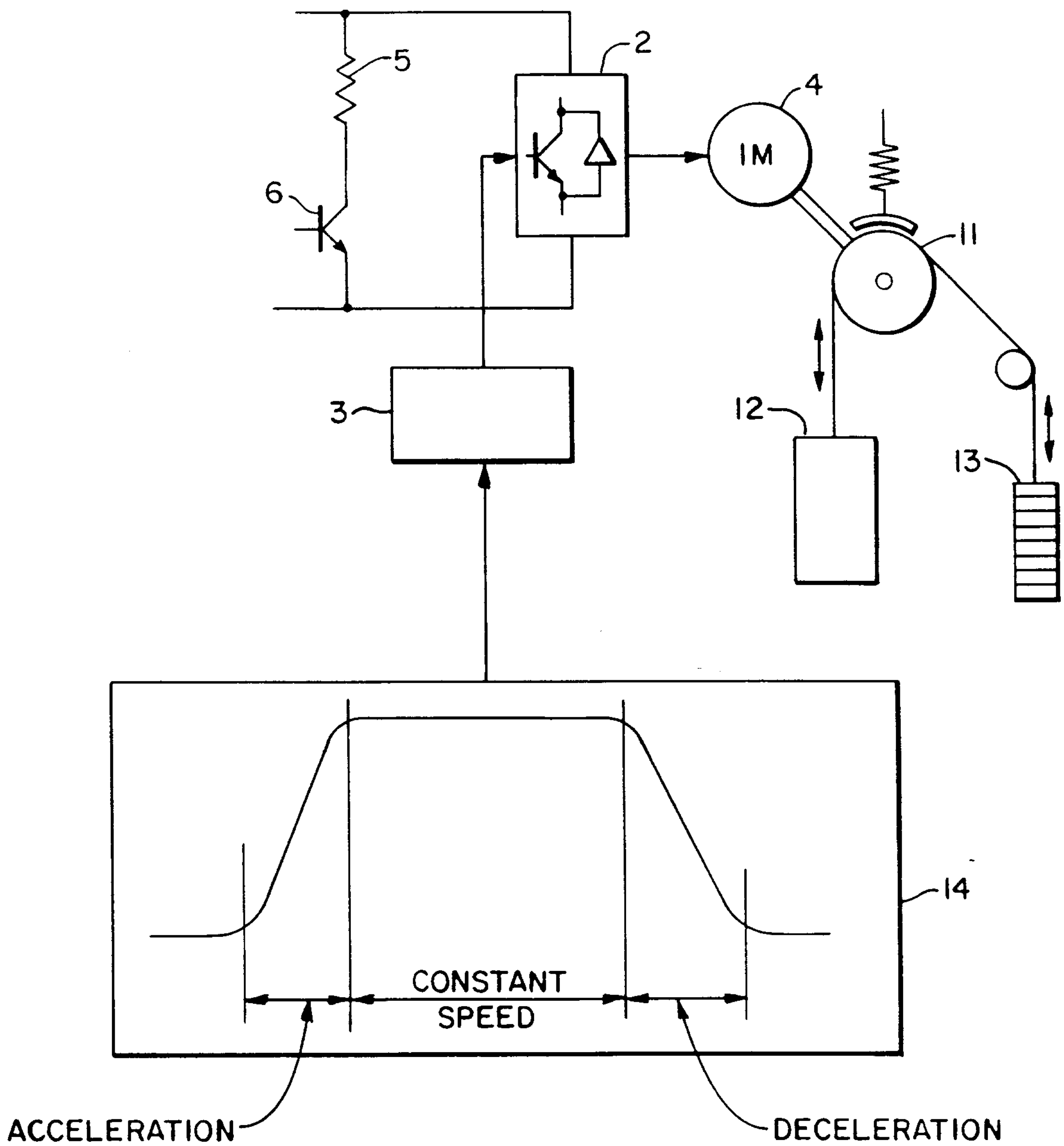
5
2
4
IM
11
6
3
12
13
14
CONSTANT
SPEED
ACCELERATION
DECELERATION

FIG. 5

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EUROPEAN SEARCH REPORT

Application Number

EP 93 30 0435

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	EP-A-0 314 801 (FANUC LTD) * page 14, line 1 - page 16, line 20; figures 5,6 * ---	1-4	B66B1/30
A	GB-A-2 167 252 (MITSUBISHI DENKI K.K) * page 3, line 85 - page 4, line 26; figures 2,3 * ---	1,2	
A	US-A-4 545 464 (NOMURA) * column 4, line 39 - line 64; figure 2 * ---	1,2,5	
A	WO-A-8 806 817 (OTIS ELEVATOR COMPANY) * page 8, line 4 - page 11, line 18; figures 1,2 * -----	1,2	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

B66B
H02P

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	30 AUGUST 1993	CLEARY F.M.

CATEGORY OF CITED DOCUMENTS

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