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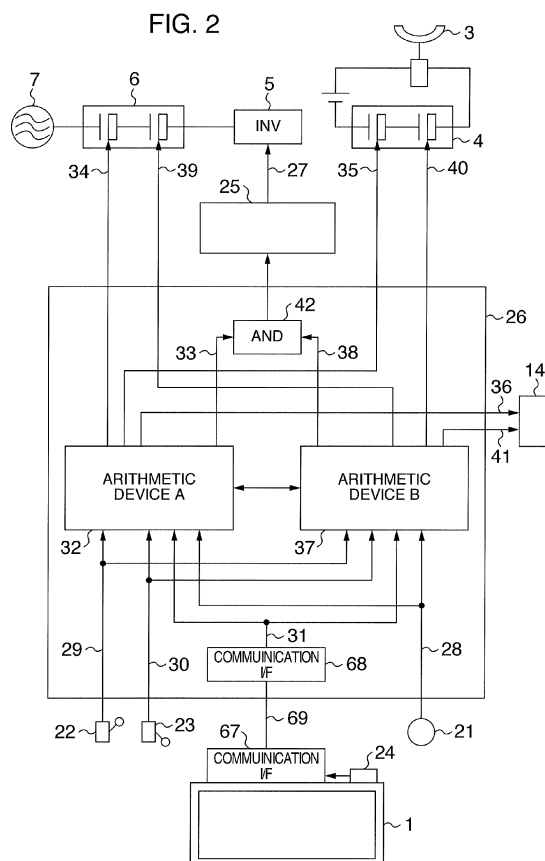
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(54) **Elevator**

(57) An elevator includes an arithmetic device (32, 37) that incorporates a comparing unit (46) for comparing a car speed  $V_1$  calculated by using an encoder signal (28) from an encoder (21) with a car speed  $V_2$  calculated by using an acceleration sensor signal (31) from an acceleration sensor (24) installed on a car (1) to detect a failure of the encoder (21) by determining whether a difference between the car speeds  $V_1$  and  $V_2$  is present in a predetermined range, thereby, a failure diagnosis in the arithmetic device is carried out in low cost and high reliability.



## Description

### BACKGROUND OF THE INVENTION

**[0001]** The present invention relates to an elevator providing a failsafe system for electronically realizing a protective function from hazardous events.

**[0002]** The failsafe system basically equipped in the elevator has been known as a configuration such that an excess from a normal operation range of a car is detected by final limit switches installed at the upper and lower portions of a hoistway to thereby stop the car by activating a brake furnished to a motor etc. for driving a primary rope of the car and cutting off a power to be supplied to a drive motor for a hoist etc. Another alternative failsafe system has been an emergency stop system furnished on the car. This emergency stop system is configured such that it activates a grip rail to make the car stop immediately when detecting an excessive speed of the car.

**[0003]** In a mechanism for activating a stopping unit of the car, electrical components such as a switch, relay, contactor, etc. have been used for activating the brake and cutting off the power, and mechanical components such as a governor, governor rope, etc. have been used for the emergency stop system. However, in recent years, such mechanism tends towards an electronic control. An electronic failsafe system uses input information from sensors relative to the switches, encoders, etc. to carry out an operation in an arithmetic device, and it then outputs a signal to activate the stopping unit of car when detecting the hazardous event. With the electronically operated failsafe system described above, an advanced failsafe function can be realized, such as an emergency terminal speed-limiting function.

**[0004]** WO2004/076326 discloses the emergency terminal speed-limiting function in which a speed upper-limit of the car can be set variably for activating the stopping unit in response to the position of car in the hoistway. That is, a first speed upper-limit is set and a second speed upper-limit faster than that is also set. The brake is activated to cut off the power when the car exceeds the first speed upper-limit, and the emergency stop system is activated when the car exceeds the second speed upper-limit. For a purpose of enhancing reliability of the failsafe system, WO2005/049467 discloses a configuration in which CPU (Central Processing Unit) as arithmetic device is duplicated to determine an activation of the stopping unit by comparing and collating computed results between two CPUs to then make the car stop when detecting an inconsistency, and the encoder installed on the governor is duplicated for detecting the position and speed of the car to compare and collate two encoded signals in the arithmetic device to then make it stop when detecting the inconsistency.

### SUMMARY OF THE INVENTION

**[0005]** However, the cost is high since the existing el-

evator has the duplicated encoders provided in the governor for detecting the position and speed of the car. In addition, there is a possibility that the both sensors would be failed simultaneously by causing a common-caused failure in the same duplicated type sensors. For example, the arithmetic device cannot detect the failure of sensors when it occurs such that the same duplicated type sensors output a zero-output simultaneously. There is also a possibility that the car cannot stop safely when another failure occurs at the same time of underlying the failure.

**[0006]** The invention is made in light of the above described problems, and an object of the invention is to provide a safer elevator capable of carrying out a failure diagnosis in the arithmetic device in low cost and high reliability.

**[0007]** In order to achieve the above described object, the invention provides an elevator comprising an arithmetic device that receives signals from a plurality of sensors for detecting operating states of a car to determine an abnormality and control the car by an abnormality determination signal, wherein an acceleration sensor is provided on the car, and the arithmetic device includes a computing unit that receives signals from the acceleration sensor, a speed detection unit different from the acceleration sensor to respectively calculate car speeds and/or a comparing unit that compares two calculated car speeds in the arithmetic device to output the abnormality determination signal in accordance with a compared result.

**[0008]** According to the above described configuration, the comparing unit can compare a car speed V2 calculated from a signal of the acceleration sensor installed on the car with a car speed V1 calculated from the speed detection unit. Therefore, a possibility of raising a common-caused failure is removed with a concern caused by supplying detected signals to the arithmetic devices from the same type of sensors in the past. In this way, it can be determined that whether either the acceleration sensor or the speed detection unit is normally functioned and either of these is failed. A failure diagnosis is also carried out by using the acceleration sensor in low cost and high reliability, so that a safer elevator can be provided.

**[0009]** In addition to the above described configuration, the arithmetic device outputs the abnormality determination signal for making the car stop, when a difference between the both car speeds becomes larger than a predetermined value by using a compared result of the two car speeds in the comparing unit.

**[0010]** According to the above described configuration, the car be stopped at a time when the difference between the both speeds becomes larger than the predetermined value while preventing an error operation caused by an error in the speed calculation, therefore, the safer elevator can be provided.

**[0011]** In addition to the above described configuration, the arithmetic device includes a correction unit that resets the car speed calculated in accordance with the

signal from the acceleration sensor to zero at every time of stopping the car.

**[0012]** According to the above described configuration, at a time of stopping the car, the car speed V2 calculated in the car speed calculation unit is reset to zero by using the acceleration sensor signal fetched from the acceleration sensor. Therefore, an accumulation of error caused by an integration calculation for a long period of time in the speed calculation can be prevented, and the car speed V2 calculated from the acceleration sensor can also be prevented from dissociating from the car speed V1 calculated in the speed detection unit.

**[0013]** In addition to the above described configuration, an offset measuring unit is provided in a correction unit, for measuring an offset of the acceleration sensor at every time of stopping the car, and the car speed calculation unit is provided in the computing unit, for calculating the car speed acquired from the acceleration sensor by using the offset from the offset measuring unit.

**[0014]** According to the above described configuration, the car speed V2 can be calculated in high accuracy while correcting the occurrence of error difference, even though the acceleration sensor is used. Therefore, the comparison with the car speed V1 calculated in the speed detection unit can be carried out in higher accuracy.

**[0015]** In also addition to the above described configuration, the speed detection unit is an encoder.

**[0016]** According to the above described configuration, the encoder installed on a normally operating elevator can be used, and a combination with the acceleration sensor simpler in structure compared with the encoder can also be used. Therefore, the high reliable arithmetic device can be provided without making the entire configuration complicated.

**[0017]** In addition to the above described configuration, a third speed detection unit is further provided in the elevator, different in the calculation for the two car speeds, and the computing unit includes a speed calculation unit that corrects the car speed calculated in accordance with the signal from the acceleration sensor on an operation of the car by using a car speed calculated in accordance with a signal from the third speed detection unit.

**[0018]** According to the above described configuration, not only the car speed V2 calculated from the acceleration sensor can be prevented from dissociating from the car speed V1 calculated from the speed detection unit even in the operation of the car, but also the comparison can be invalidated at a time of occurring a skidding in the encoder, as the third speed detection unit, located on the side of the primary rope, therefore, the safer elevator can be provided while carrying out the failure diagnosis in higher accuracy.

**[0019]** In addition to the above described configuration, a communication line is provided for transmitting a digital signal, to the arithmetic device, converted from the signal from the acceleration sensor installed on the car.

**[0020]** According to the above described configura-

tion, a sufficient signal accuracy cannot be obtained by affecting a voltage drop and noise when transmitting the signal, remained as an analog signal, of acceleration sensor. However, by using the communication line, a high accuracy control is carried out with reduction of affecting the voltage drop and noise even though a distance between the car and the arithmetic device becomes long, so that the arithmetic device can be installed on a desirable location even though the acceleration sensor is installed on the car.

**[0021]** According to the elevator of the invention, the car speeds are calculated by fetching the signals from the acceleration sensor installed on the car and a sensor different from the acceleration sensor, and the car is controlled by the difference between the car speeds, therefore, the possibility of raising the common-caused failure is removed with the concern caused by duplicating the same type of sensors, so that the reliability of failure diagnosis can be enhanced to provide a highly safe elevator.

**[0022]** The other objects, features and advantages of the invention will become apparent from the following description of the embodiments of the invention taken in conjunction with the accompanying drawings.

## BRIEF DESCRIPTION OF THE DRAWINGS

### [0023]

Fig. 1 is an entire configuration diagram showing an elevator in one embodiment of the invention;  
Fig. 2 is a signal connection wiring diagram of the elevator in Fig. 1;  
Fig. 3 is a functional block diagram showing an arithmetic device shown in Fig. 2;  
Fig. 4 is a block diagram for explaining a processing in the arithmetic device in Fig. 3;  
Fig. 5 is a signal connection wiring diagram of the elevator in another embodiment of the invention;  
Fig. 6 is a functional block diagram showing the arithmetic device in Fig. 5;  
Fig. 7 is a block diagram for explaining the processing in the arithmetic device in Fig. 6;  
Fig. 8 is a flowchart showing the processing of the arithmetic device in the elevator in the another embodiment of the invention; and  
Fig. 9 is a time chart showing a car speed correction processing of the elevator in another embodiment of the invention.

## DESCRIPTION OF THE EMBODIMENTS

**[0024]** Hereinafter, embodiments of the invention will be described with reference to the drawings.

**[0025]** Fig. 1 is an entire configuration diagram of an elevator in one embodiment of the invention. In Fig. 1, the elevator is configured such that a car 1 is coupled to one end of a primary rope 10, a counterweight 11 is hung

near on the other end of the primary rope 10, and the car 1 is moved up and down in a hoistway with the primary rope 10 driven by a motor 2. The motor 2 is activated through an inverter 5 coupled with an AC power source 7 via a power cutting-off circuit 6, and the power cutting-off circuit 6 is activated to cut off a power supply to the inverter 5. A braking device 3 is also installed to control the drive of motor 2 and generate a braking force for the car 1. This braking device 3 is configured such that it is situated in a braking state at a steady state, and the braking state is released when supplying the power.

**[0026]** A governor rope 12 driven with the car 1 moving up and down makes rotate a governor 13, and this governor 13 provides a gripping device 14 and an encoder 21. The gripping device 14 is activated to grip the governor rope 12, and an emergency stop system 15 therefore sandwiches a rail 16 to stop the car 1 on operation. The encoder 21 rotates with governor 13 to generate a pulse signal, and a variation of the pulse signal is counted up to calculate a position of the car 1. A time average of the variation is calculated to be able to acquire a speed of the car 1. An acceleration sensor 24 is also installed on the car 1, and an acceleration sensor signal is integrated to be able to calculate the speed of car 1. It is desirable to use MEMS (Micro-Electro-Mechanical Systems) sensor, as acceleration sensor 24, manufactured by using the semiconductor manufacturing technology, since it is inexpensive price and high accuracy.

**[0027]** A buffer 17 is installed on a lower end of the hoistway to receive the car 1 and absorb its impact even when the car 1 cannot be stopped completely by the braking force of the braking device 3 and emergency stop system 15. Final limit switches 22, 23 are installed near the lower and upper ends of the hoistway to detect an excess of moving the car 1. The final limit switches 22, 23 are a normally closed state, however, they become an open state when the car 1 passes through the final limit switch 22 or 23 and moves to the upward or downward. A controller 25 and a safety controller 26 are installed in a control panel located near the hoistway. The controller 25 controls the inverter 5 to operate the car 1, and the safety controller 26 receives signals from the encoder 21, final limit switches 22, 23 and acceleration sensor 24 to detect a hazardous event and activate the emergency stop system 15 via the braking device 3, power cutting-off circuit 6 and gripping device 14. In this way, the car 1 is braked to avoid the hazardous event. In addition, a number of safety switches (not shown), used for protecting workers in a maintenance period etc., are installed on the elevator, other than the final limit switches 22, 23.

**[0028]** Fig. 2 is a signal connection wiring diagram of the elevator shown in Fig. 1. The controller 25 outputs an inverter control signal 27 to control the inverter 5. The safety controller 26 provides arithmetic devices 32, 37, and these arithmetic devices 32, 37 may be configured by hardware, and may also be configured by a micro-computer having ROM (Read Only Memory), RAM (Ran-

dom Access Memory) and peripheral circuits served as digital input and output, encoder input, analog input, etc., each of which is coupled to CPU (Central Processing Unit) by an internal bus.

**[0029]** The input of the arithmetic devices 32, 37 contains an encoder signal 28 from the encoder 21, switching signals 29, 30 respectively from the final limit switches 22, 23, and an acceleration sensor signal 31 from the acceleration sensor 24.

**[0030]** When the acceleration sensor signal 31 from the acceleration sensor 24 is fetched to the safety controller 26, a communication interface 67 located on the side of acceleration sensor 24 installed on a ceiling of the car 1 is coupled, by a communication line 69, with a communication interface 68 located on the side of the safety controller 26 installed on an appropriate position to transmit the acceleration sensor signal 31 converted into a digital signal, to the arithmetic devices 32, 37 in the safety controller 26 through the communication line 69. The acceleration sensor signal 31 can be fetched to the safety controller 26 by the other method. However, since the digital signal is transmitted to the arithmetic devices 32, 37 by using the communication line 69 as described above, the signal of acceleration sensor 24 can be transmitted to the arithmetic devices 32, 37 without affecting by a voltage drop and a noise even though a distance between the acceleration sensor 24 installed on the car 1 and the safety controller 26 placed on a desirable position becomes long.

**[0031]** In contrast, an output from the arithmetic device 32 contains a stop request signal 33 supplied to an AND circuit 42, a switching signal 34 to a contactor in the power cutting-off circuit 6, a switching signal 35 to a brake driving circuit 4 supplied to the power to the braking device 3 and an emergency stop activating signal 36 to the gripping device 14. Likewise, an output from the arithmetic device 37 contains a stop request signal 38 supplied to the AND circuit 42, a switching signal 39 to the contractor in the power cutting-off circuit 6, a switching signal 40 to the brake driving circuit 4 and an emergency stop activating signal 41 to the gripping device 14. The eight output signals from the arithmetic devices 32, 37 are a stop output for activating a stopping system of the car 1.

**[0032]** The stop request signals 33, 38 are used for controlling and stopping the car 1 by the controller 25: a signal level High means that the stop request is absent; and a signal level Low means that the stop request is present. These signals are output to the controller 25 via the AND circuit 42, and the controller 25 controls the inverter 5 by the inverter control signal 27 to stop the car 1 when either the stop request signal 33 or 38 becomes Low.

**[0033]** The switching signals 34, 39 are fed to the series-connected two contactors in the power cutting-off circuit 6: the contactors are switched to a coupled state when the switching signals 34, 39 are On and to a decoupled state when they are Off. Since the two contactors are coupled in series, the power cutting-off circuit 6 cuts

off the power between the AC power source 7 and inverter 5 when either the switching signal 34 or 39 becomes Off.

**[0034]** The switching signals 35, 40 are fed to the two contactors coupled in series in the brake driving circuit 4: the contactors are switched to the coupled state when the switching signals 35, 40 are On; and to the decoupled state when they are Off. Since the two contactors are coupled in series, the brake driving circuit 4 makes cut off the power to the braking device 3 to set it to a braking state when either the switching signal 35 or 40 becomes Off.

**[0035]** The emergency stop activating signals 36, 41 are fed to a solenoid for actuating the gripping device 14: the gripping device 14 is made to an inactive state when the both emergency stop activating signals 36, 41 are On; and the gripping device 14 is activated when either the signal 36 or 41 is Off. In this way, the emergency stop system 15 sandwiches the rail 16 to make the car 1 stop on the operation in the hoistway.

**[0036]** Fig. 3 is a block diagram showing the arithmetic device 32, and the arithmetic device 37 is also the same configuration as that. The arithmetic device 32 is configured by a computing unit 43, an input unit 44, an output unit 45 and a comparing unit 46. These units may be configured by hardware, and may also be realized by programs stored in ROM located inside or outside the microcomputer and executed by CPU incorporated in that.

**[0037]** The input unit 44 receives and processes the encoder signal 28, final limit switch signals 29, 30, acceleration sensor signal 31 and safety switching signals (not shown). The encoder signal 28 is converted to a value indicating the speed and position of the car 1, and On and Off of switching signals 29, 30 are replaced with High and Low, respectively. The output unit 45 outputs a car stop signal becoming Low, as a computed result from the computing unit 43, at which the car 1 stops. The comparing unit 46 compares a car speed V1 computed from the encoder signal 28 by the computing unit 43 with a car speed V2 computed from the acceleration sensor signal 31 to determine whether a difference between the both is present in a predetermined range.

**[0038]** When a determined result is not present in the predetermined range, the comparing unit 46 determines that either the encoder 21 or acceleration sensor 24 is failed to feed the stop request signals 33, 38 to be supplied to the inverter 5, switching signals 34, 39 to the power cutting-off circuit 6 and switching signals 35, 40 to the brake driving circuit 4, as an abnormality determination signal for making the car 1 stop, to the output unit 45. The comparing unit 46 compares the computed result of the arithmetic device 37 with that of the arithmetic device 32, as described above, to determine whether the both devices are operated normally. When the compared result for both devices is inconsistent, likewise, the abnormality determination signal is fed to the output unit 45 so that the car 1 stops.

**[0039]** Fig. 4 is a block diagram for explaining an abnormality determination processing executed in the computing unit 43. The input unit is omitted from Fig. 4 for the sake of simplicity. The computing unit 43 incorporates a safety-chain abnormality-determination unit 47 and an emergency terminal over-speed abnormality-determination unit 48. The safety-chain abnormality-determination unit 47 outputs Low when either the safety switch, containing the final limit switch 22 or 23, is Off, that is, either the switching signal 29 or 30 is Low. The safety-chain abnormality-determination unit 47 also makes the switching signals 34, 35 Low, from the output unit 45 to request the activation of braking drive 3 and power cutting-off circuit 6.

**[0040]** The emergency terminal over-speed abnormality-determination unit 48 holds a first speed upper-limit curve 49 and a second speed upper-limit curve 50 illustrated respectively on a horizontal axis indicating a position of the car 1 in the hoistway and a vertical axis indicating a speed of that, as a table data. The emergency terminal over-speed abnormality-determination unit 48 calculates a first speed upper-limit in response to the position of car 1 from the first speed upper-limit curve 49 to output Low when the speed of car 1 exceeds the first speed upper-limit. The emergency terminal over-speed abnormality-determination unit 48 also makes the switching signals 34, 35 Low, from the output unit 45 to request the activation of brake drive 3 and power cutting-off circuit 6. In contrast, the emergency terminal over-speed abnormality-determination unit 48 calculates a second speed upper-limit in response to the position of car 1 from the second speed upper-limit curve 50 to output Low when the speed of car 1 exceeds the second speed upper-limit. The emergency terminal over-speed abnormality-determination unit 48 also makes the emergency stop activating signal 36 Low, from the output unit 45 to request the activation of emergency stop system 15 via the gripping device 14.

**[0041]** The computing unit 43 feeds the car speed V1 calculated by using the car position and speed calculated from the encoder signal 28 of the encoder 21 in a car position and speed calculation unit 51 and the car speed V2 calculated from the acceleration sensor signal 31 of the acceleration sensor 24 in a car speed calculation unit 52, to the comparing unit 46 to compare with the both. The processing carried out by using the car speeds V1 and V2 in the comparing unit 46 determines whether the difference between the both is present in the predetermined range as described above. When the determined result is not present in the predetermined range, the comparing unit 46 determines that either the encoder 21 or acceleration sensor 24 is failed to control the output unit 45 such that the abnormality determination signal, containing the stop request signals 33, 38 to be supplied to the inverter 5, switching signals 34, 39 to the power cutting-off circuit 6 and switching signals 35, 40 to the brake driving circuit 4, makes the car 1 stop, and also notify an abnormality occurrence of the arithmetic devices 32, 37.

In contrast, when the both speeds are present in the predetermined range, it is determined that the arithmetic devices 32, 37 are normal.

**[0042]** According to the above described embodiment of the elevator, the comparing unit 46 in the arithmetic devices 32, 37 compares the car speed V1 calculated by using the encoder signal 28 output from the encoder 21 with the car speed V2 calculated by using the acceleration sensor signal 31 output from the acceleration sensor 24, installed on the car 1, unlike the encoder 21. In this way, it is determined that the arithmetic devices 32, 37 are operated normally by determining whether the difference between the car speeds V1 and V2 is present in the predetermined range. Therefore, a possibility of raising a common-caused failure can be removed with a concern caused by supplying detected signals to the arithmetic devices from the same type of sensors in the past. A failure diagnosis is carried out by using the acceleration sensor in low cost and high reliability, so that a safer elevator can be provided.

**[0043]** The encoder installed on a normally operating elevator can be used for calculating the car speed V1 of one car, and the acceleration sensor simpler than in structure compared with the encoder can be used for calculating the car speed V2 of the other. Therefore, the high reliable arithmetic device can be provided without making the entire configuration complicated. Furthermore, since the car speed V2 to be compared in the comparing unit 46 is calculated by using the acceleration sensor 24 additionally installed on the car 1, an inexpensive semiconductor type MEMS sensor compared with the encoder 21 can be used for the acceleration sensor 24. Therefore, an inexpensive system can be realized, compared with that duplicating the encoder 21.

**[0044]** Moreover, since the output signal of acceleration sensor 24 installed on the car 1 is converted to transmit to the arithmetic devices 32, 37 through the communication line 69, a sufficient signal accuracy cannot be obtained by affecting the voltage drop and noise when transmitting the signal, remained as analog signal, of acceleration sensor 24. However, by using the communication line 69, a high accuracy control can be carried out without affecting by the voltage drop and noise even though the acceleration sensor 24 is installed on the car 1 and the distance between the car 1 and the arithmetic devices 32, 37 becomes long caused by installing the arithmetic devices 32, 37 on a desirable position.

**[0045]** Incidentally, an integration calculation is carried out for calculating the car speeds V1, V2 from the acceleration sensor signal 31 output from the acceleration sensor 24, but the integration calculation for a long period of time causes to accumulate error. The car speed V2 calculated from the acceleration sensor signal 31 is dissociated from the car speed V1 calculated from the encoder signal 28, therefore, there is a possibility that the elevator is stopped, even though the encoder 21 and acceleration sensor 24 are normal.

**[0046]** Fig. 5 is a signal connection wiring diagram on

the basis of another embodiment of the invention for solving the above described problem. A description for elements in Fig. 5 is omitted for those designating the same reference numerals in Fig. 2, and the elements different in Fig. 2 will be described below. The arithmetic devices 32, 37 receive state signals 53, 55 indicating a present state of the power cutting-off circuit 6 and state signals 54, 56 indicating the present state of the brake driving circuit 4, respectively. The contactors in power cutting-off circuit 6 can be controlled by not only the switching signals 34, 39, but also a switching signal 57 from the controller 25. Likewise, the contactors in the brake driving circuit 4 can be controlled by not only the switching signals 35, 40, but also a switching signal 58 from the controller 25.

**[0047]** Therefore, the contactors in the brake driving circuit 4 and power cutting-off circuit 6 can be controlled not only by the safety controller 26 but also by the switching signals 57, 58 from the controller 25, respectively, to cut off the power supplied to the inverter 5 and to the braking drive 3. Therefore, at a time of the normal, the brake driving circuit 4 and power cutting-off circuit 6 are controlled by the switching signals 57, 58 output from the controller 25 at every time of arriving the car 1 at a designated floor to cut off the power supplied to the inverter 5 and braking drive 3 and make the car 1 stop. The arithmetic devices 32, 37 in the safety controller 26 fetch the state signals 53 to 56 indicating the state of the power cutting-off circuit 6 and brake driving circuit 4 so as to detect the stop of car 1.

**[0048]** The arithmetic devices 32, 37 are identical configuration, likewise, described above. Here, the arithmetic device 32 will be described below. The arithmetic device 32 provides a correction unit 60 as shown in Fig. 6, in addition to the configuration having the computing unit 43, input unit 44, output unit 45 and comparing unit 46 as illustrated in Fig. 3. The correction unit 60 receives the state signals 53, 54 indicating the state of power cutting-off circuit 6 and brake driving circuit 4, and also receives the acceleration sensor signal 31 output from the acceleration sensor 24 to feed a corrected signal 61, after processed, to the computing unit 43. A specific processing in the correction unit 60 will be described with reference to Fig. 7.

**[0049]** Fig. 7 is a block diagram showing the abnormality determination processing, which is different in that the correction unit 60 is added to the computing unit 43. The correction unit 60 has a car stop determination unit 62 and an offset measuring unit 63. The car stop determination unit 62 fetches the state signals 53, 54 indicating the present state of power cutting-off circuit 6 and brake driving circuit 4 to determine whether the car 1 is being stopped. When the car stop determination unit 62 determines that the car 1 is being stopped, it feeds a reset signal 64, as the corrected signal 61 shown in Fig. 6, to a car speed calculation unit 52 to reset the car speed V2 calculated in the car speed calculation unit 52 to zero.

**[0050]** When the offset measuring unit 63 determines

that the car 1 is being stopped by the car stop determination unit 62, a difference from an offset value  $\alpha 0$  or 1G (gravity acceleration) is measured by using the acceleration sensor signal 31 from the acceleration sensor 24 to feed an offset signal 65, as the corrected signal 61 shown in Fig. 6, to the car speed calculation unit 52. Here, the car stop determination unit 62 determines whether the car is being stopped, by the state signals 53, 54 indicating the state of the power cutting-off circuit 6 and brake driving circuit 4. Similarly, it may also be configured that a signal indicating that the car 1 is being stopped is received directly from the controller 25.

**[0051]** The car speed calculation unit 52 gives priority to the reset signal 64, when receiving it, to reset the car speed V2 calculated therein to zero and calculate the corrected car speed V2 by subtracting the offset value  $\alpha 0$  from the acceleration sensor signal 31. Thereafter, as described above, the comparing unit 46, likewise, compares the car speed V1 calculated in the car position and speed calculation unit 51 with the car speed V2 calculated in the car speed calculation unit 52 to determine whether a difference between the both is present in the predetermined range. From a determined result, it is determined that the encoder 21 and acceleration sensor 24 are normally functioned if the difference between the both is present in the predetermined range. If it is not present in the predetermined range, it is determined that either the encoder 21 or acceleration sensor 24 is failed to then output a signal for making the car 1 stop or a signal for notifying an abnormality occurrence, as the abnormality determination signal.

**[0052]** According to the above described embodiment of the elevator, the possibility of raising the common-caused failure can be removed with the concern caused by simply duplicating the same type of sensors by using the car speed V1 calculated from the encoder 21 and the car speed V2 calculated from the acceleration sensor 24, so that the reliability for the failure diagnosis of encoder can further be enhanced. Furthermore, at a time of stopping the car 1, the car speed V2 calculated in the car speed calculation unit 52 is reset to zero by using the acceleration sensor signal 31 fetched from the acceleration sensor 24. Therefore, the accumulation of error caused by the integration calculation for the long period of time can be prevented, and the car speed V2 calculated from the acceleration sensor signal 31 can also be prevented from dissociating from the car speed V1 calculated from the encoder signal 28, even though the encoder 21 and acceleration sensor 24 are normal.

**[0053]** When the car stop determination unit 62 determines that the car 1 is being stopped, the offset value  $\alpha 0$  is measured by using the acceleration sensor signal 31 from the acceleration sensor 24. The car speed calculation unit 52 subtracts the offset value  $\alpha 0$  from the acceleration sensor signal 31 to calculate the corrected car speed V2, therefore, the car speed V1 calculated from the encoder 21 can be compared with the car speed V2 calculated from the acceleration sensor 24 in high accu-

racy while correcting the difference caused by the error, even though the acceleration sensor 24 is used.

**[0054]** Fig. 8 is a flowchart showing a failure diagnosis processing for diagnosing whether the encoder 21 is failed in the duplication system of program loaded on the arithmetic devices 32, 37. The program is executed periodically by using a timer incorporated in the arithmetic devices 32, 37.

**[0055]** First, it is determined that whether the car 1 is being stopped at a step S 1. If the car 1 is being stopped, the car speed V2 is reset to zero at a step S2, and the offset value  $\alpha 0$  of the acceleration sensor 24 is measured at a step S3. The car speed V1 is calculated from the encoder signal 28 at a step S4, and the offset value  $\alpha 0$  is subtracted from the acceleration sensor signal 31 to calculate the car speed V2 by the integration calculation at a step S5. It is determined that whether the difference between the car speeds V1 and V2 is equal to or greater than the predetermined value at a step S6. If the difference is greater than the predetermined value, it is determined that the encoder 21 is failed, and the car stop signal is output at a step S7. However, if it is determined that the car 1 is not being stopped at the step S1, the correction processing is not carried out, and the processing proceeds to the step S4 as the offset value  $\alpha 0 = 0$ .

**[0056]** Fig. 9 is a time chart showing a car speed correction processing in the elevator in another embodiment of the invention. In Fig. 9, the correction processing can carry out for the car 1 even on the operation, in addition to the correction processing at a time t1 at which the car 1 stops as described above. In such correction processing of the car 1 on the operation, another encoder 70 as a third speed detection unit is installed on the side of primary rope 10, for example, of the motor 2 in addition to the speed detection unit, such as the acceleration sensor 24, encoder 21, etc. In this way, signals at times t2, t4 are fetched from the third speed detection unit, and the correction unit 60 uses a car speed V3 calculated from the third speed detection unit to be able to correct the car speed V2 calculated from the acceleration sensor 24 so that the car speed V2 is approximated to the car speed V3.

**[0057]** In this regard, the other encoder, as a third speed detection unit, is installed on the side of primary rope 10 to sometimes generate a slip 66 on it in general, and this slip 66 is detected as a possible risk such that it should be corrected as a difference occurrence. Therefore, a rapid speed variation of the car speed V3, calculated from the encoder on the side of primary rope 10, is monitored to detect it as an occurrence of the slip 66 when detecting the rapid speed variation at a time t3. It is possible to take measures not to carry out the correction for the period during which the slip occurs.

**[0058]** According to the above described elevator, the possibility of raising the common-caused failure can be removed with the concern caused by duplicating the same type of sensors, by carrying out the failure diagnosis of the encoder 21 configuring one of the duplication

system with use of the acceleration sensor 24, as a different type, configuring the other thereof, so that the reliability for the failure diagnosis of encoder can be enhanced and a highly safe elevator can be provided. The error caused by the integration calculation is accumulated for the long period of time in the case of using the acceleration sensor 24. This makes the dissociation possibly large from the car speed V1 calculated from the encoder signal 28 of the encoder 21. However, it takes a characteristic that the elevator does not keep operating for the long period of time, and the accumulation of the integration error is prevented by resetting the car speed V2 calculated at every time of stopping the elevator to zero and carrying out the correction on the operation with use of the encoder signal from the another encoder installed on the side of primary rope 10, so that the failure diagnosis for the encoder can be carried out correctly.

**[0059]** In addition, the above embodiments have described for either the failure diagnosis processing for the encoder 21 installed on the governor 13 or that for carrying out the comparison of the car speeds V1 and V2 calculated respectively by using the encoder 21 and acceleration sensor 24. However, another car speed detecting unit in replacement of the encoder 21 installed on the governor 13 can be used, for example, a roller-type car speed sensor installed on the car 1. The above embodiments have also described for the elevator having the duplicated arithmetic devices 32, 37, however, the invention can also be applicable to the configuration of either a single arithmetic device or the duplicated arithmetic devices 32, 37.

**[0060]** It should be further understood by those skilled in the art that although the foregoing description has been made on embodiments of the invention, the invention is not limited thereto and various changes and modifications may be made without departing from the spirit of the invention and the scope of the appended claims.

## Claims

1. An elevator comprising an arithmetic device (32, 37) that receives signals (28, 29, 30, 31) from a plurality of sensors for detecting operating states of a car (1) to determine an abnormality and control the car by an abnormality determination signal (33, 36, 38, 41), wherein  
an acceleration sensor (24) is provided on the car, and  
the arithmetic device includes a computing unit (43) that receives signals (28, 31) from the acceleration sensor and a speed detection unit (21) different from the acceleration sensor to respectively calculate car speeds (V1, V2) and a comparing unit (46) that compares two calculated car speeds (V1, V2) in the arithmetic device to output the abnormality determination signal in accordance with a compared result.
2. The elevator according to claim 1 wherein the arithmetic device (32, 37) outputs the abnormality determination signal for making the car stop when a difference of the two calculated car speeds becomes larger than a predetermined value in accordance with the compared result in the comparing unit.
3. The elevator according to claim 1 wherein the arithmetic device (32, 37) includes a correction unit (60) that resets the car speed (V2) calculated in accordance with the signal (31) from the acceleration sensor at every time of stopping the car.
4. The elevator according to claim 1 wherein an offset measuring unit (63) is provided in a correction unit (60), for measuring an offset value ( $\alpha 0$ ) of the acceleration sensor (24) at every time of stopping the car, and the computing unit (43) includes a speed calculation unit (52) that calculates the car speed (V2) regarding the acceleration sensor by using the offset value output from the offset measuring unit.
5. The elevator according to claim 1 wherein the speed detection unit (21) is an encoder.
6. The elevator according to claim 1 wherein a third speed detection unit (70) is further provided in the elevator, different in the calculation for the two car speeds (V1, V2), and the computing unit (43) includes a speed calculation unit (52) that corrects the car speed calculated in accordance with the signal (31) from the acceleration sensor on an operation of the car by using a car speed (V3) calculated in accordance with a signal from the third speed detection unit.
7. The elevator according to claim 1 wherein a communication line (69) is provided for transmitting a digital signal, to the arithmetic device (32, 37), converted from the signal (31) from the acceleration sensor installed on the car.

FIG. 1

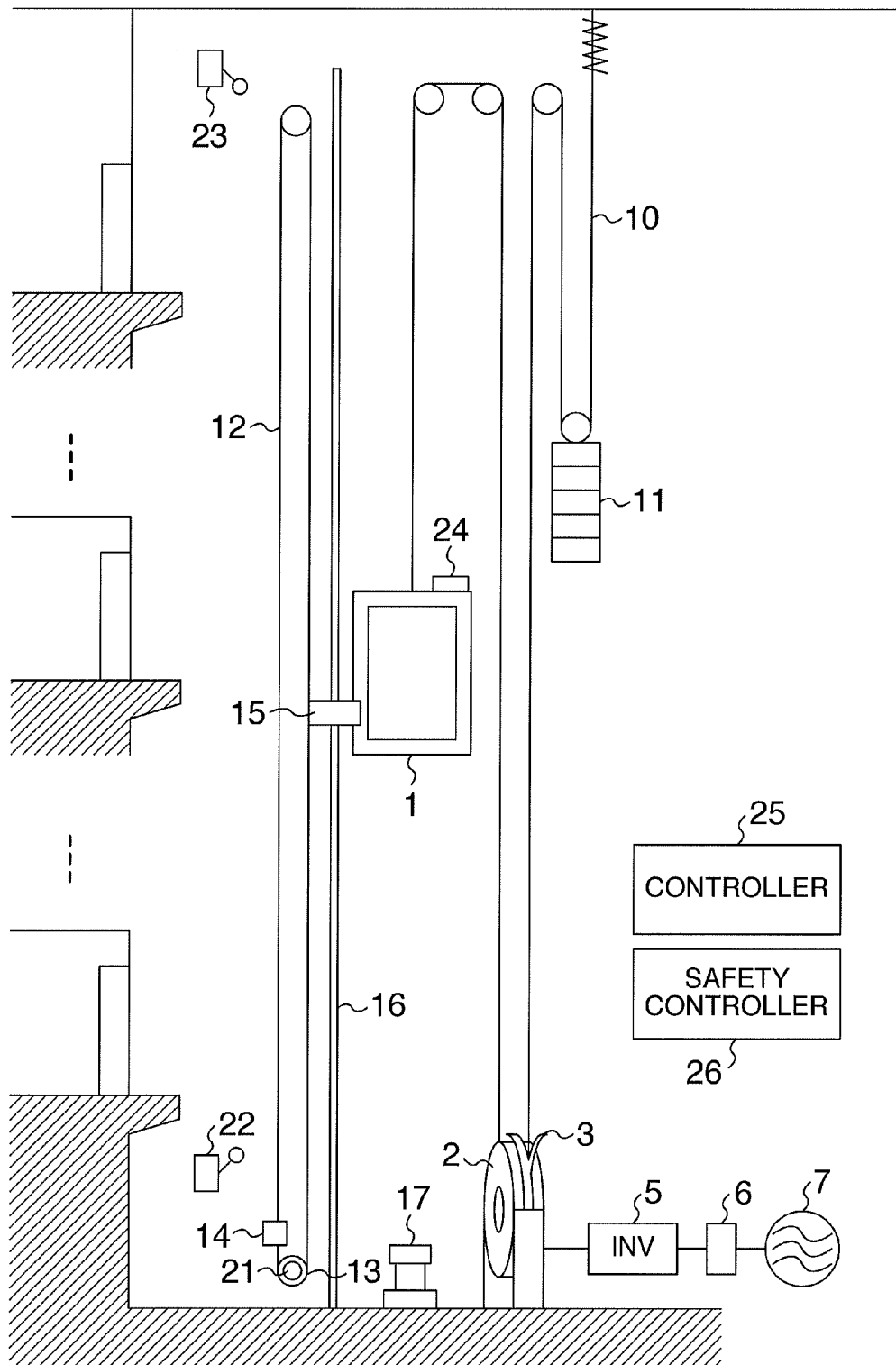


FIG. 2

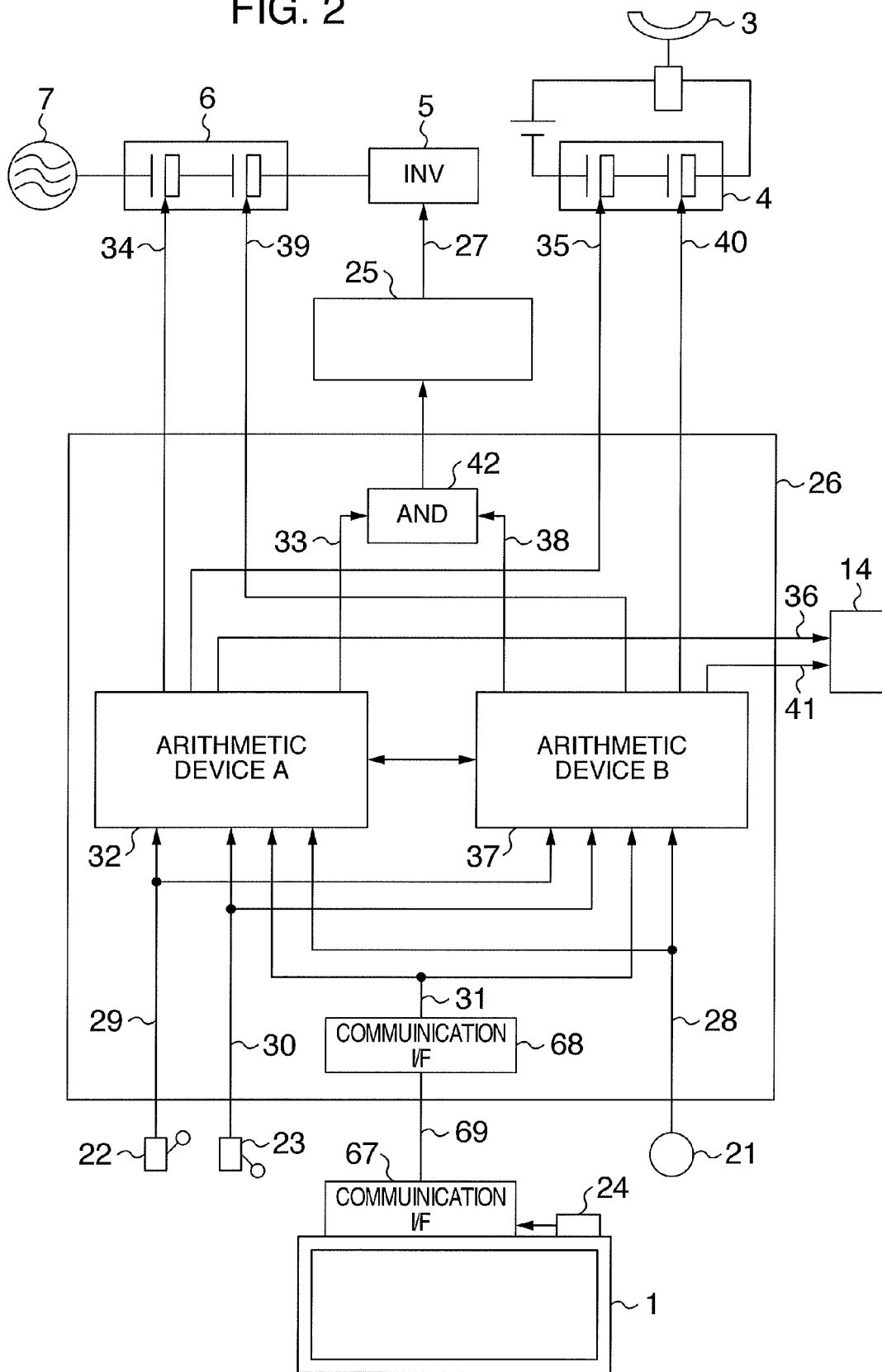


FIG. 3

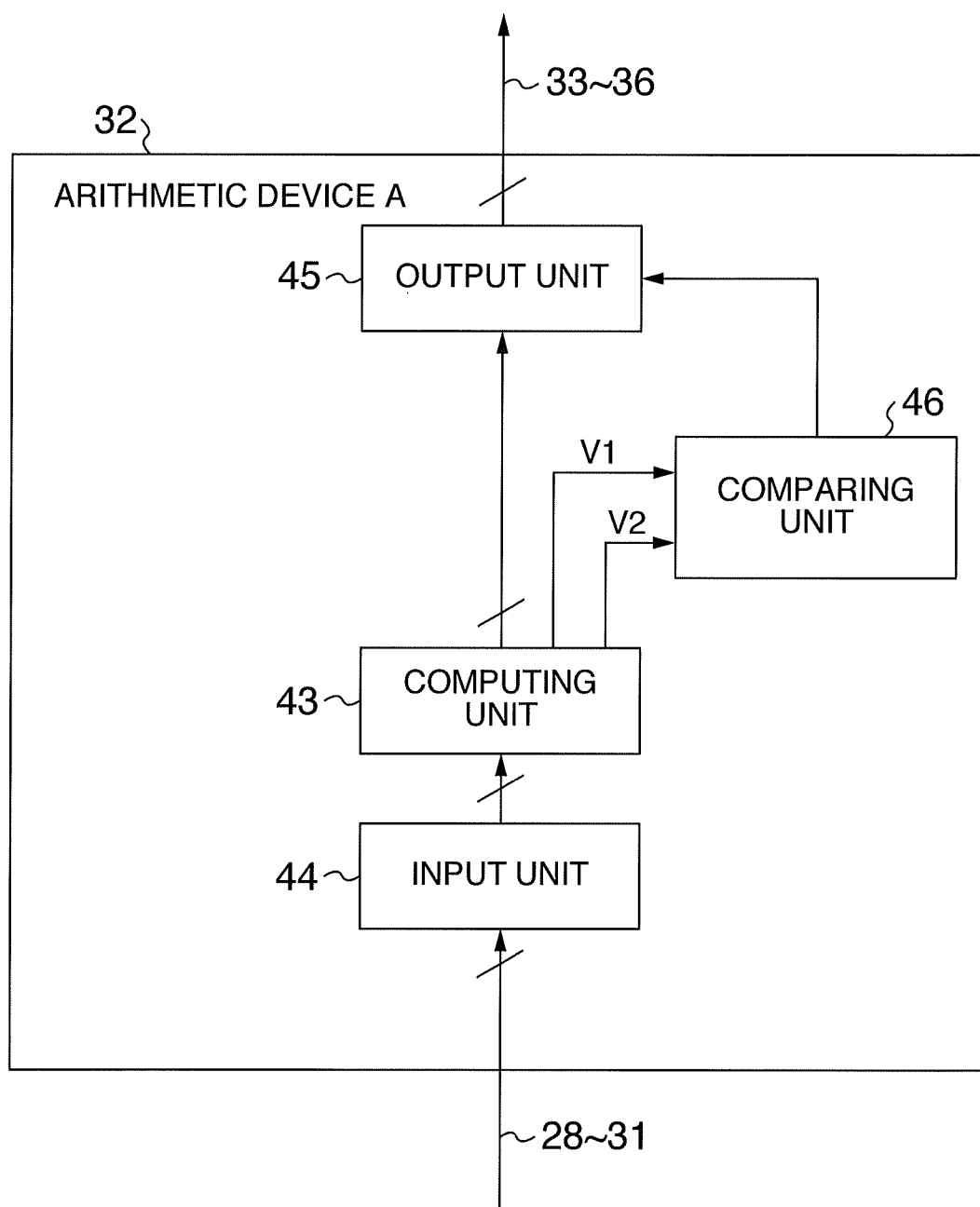


FIG. 4

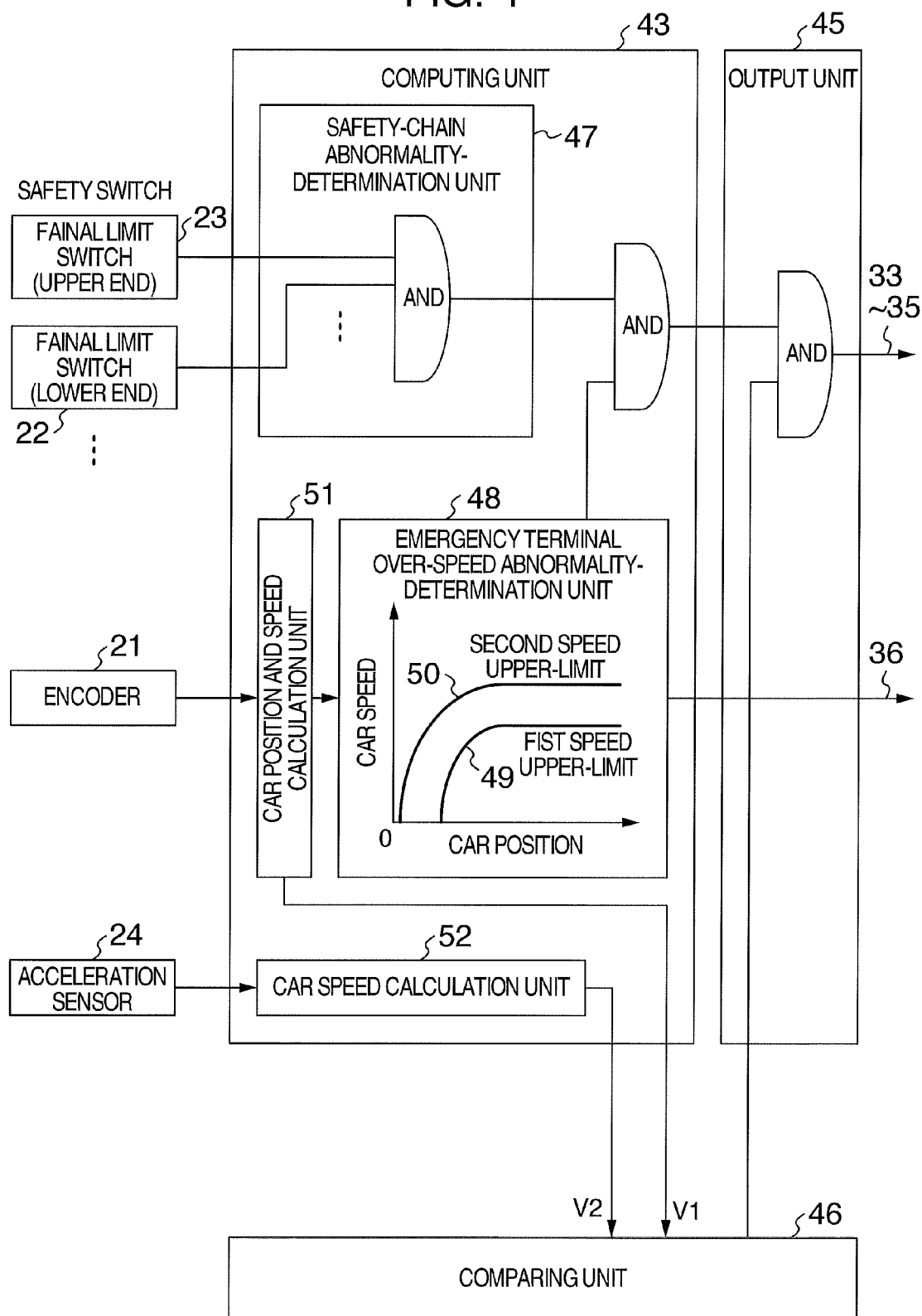


FIG. 5

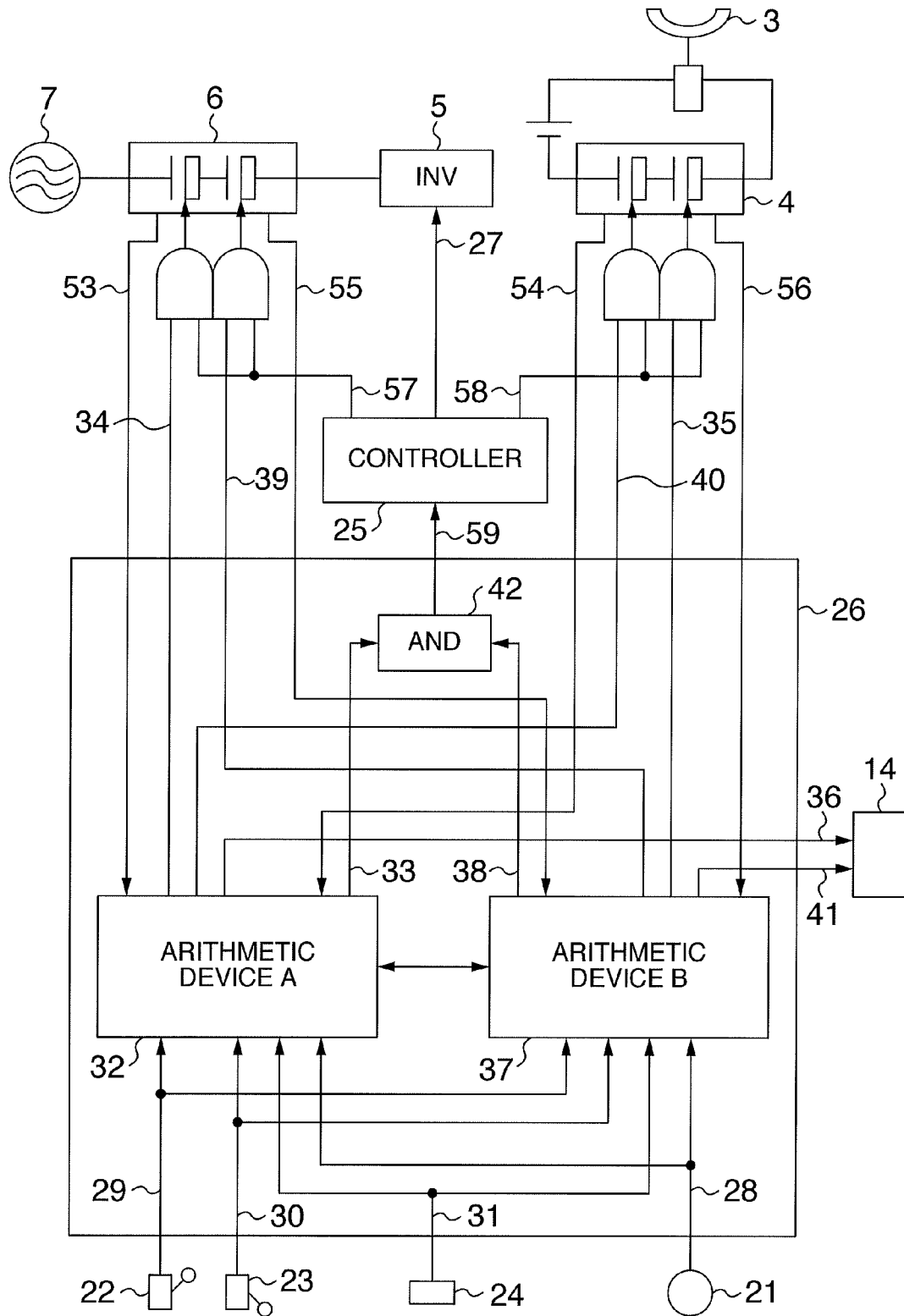


FIG. 6

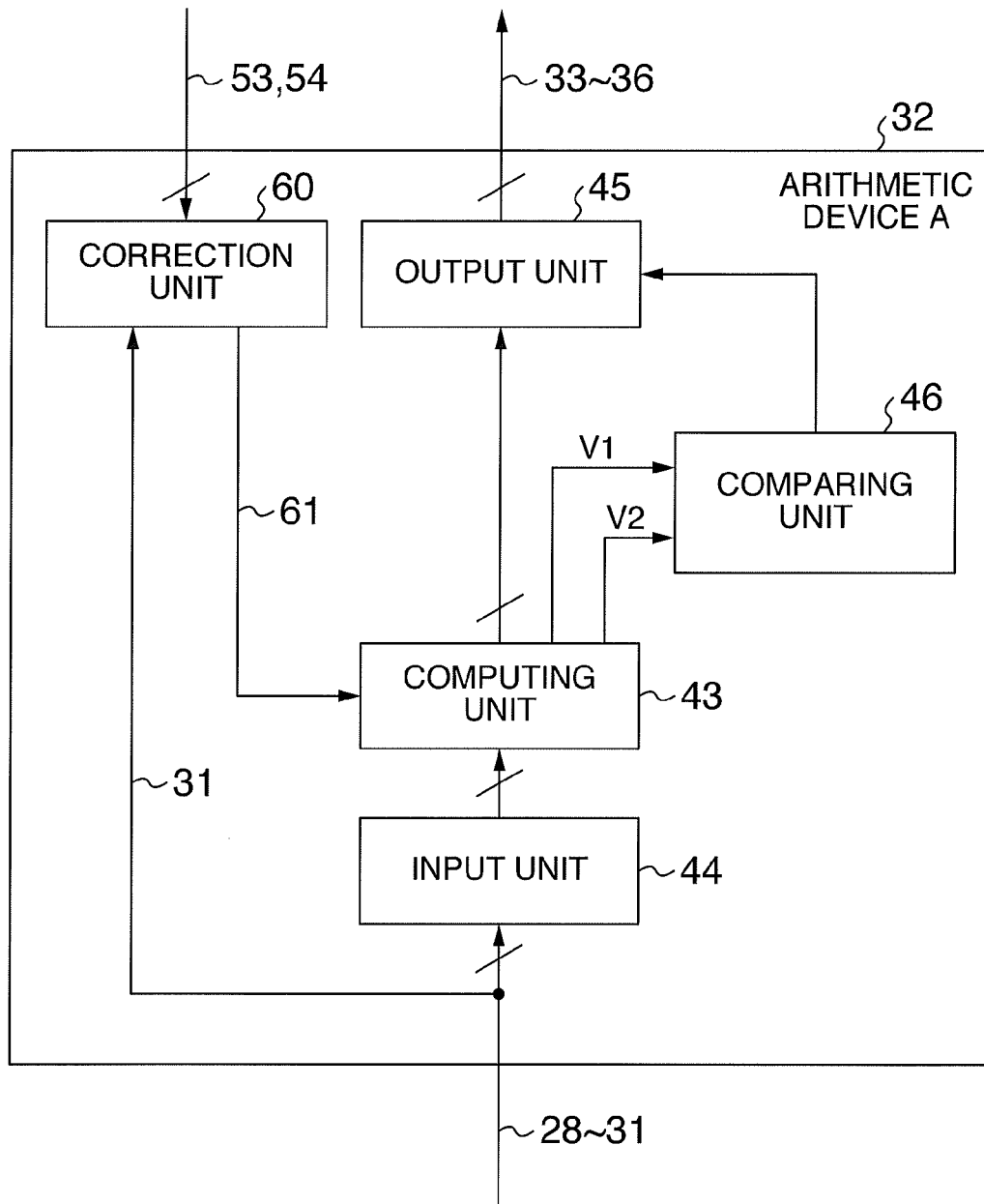


FIG. 7

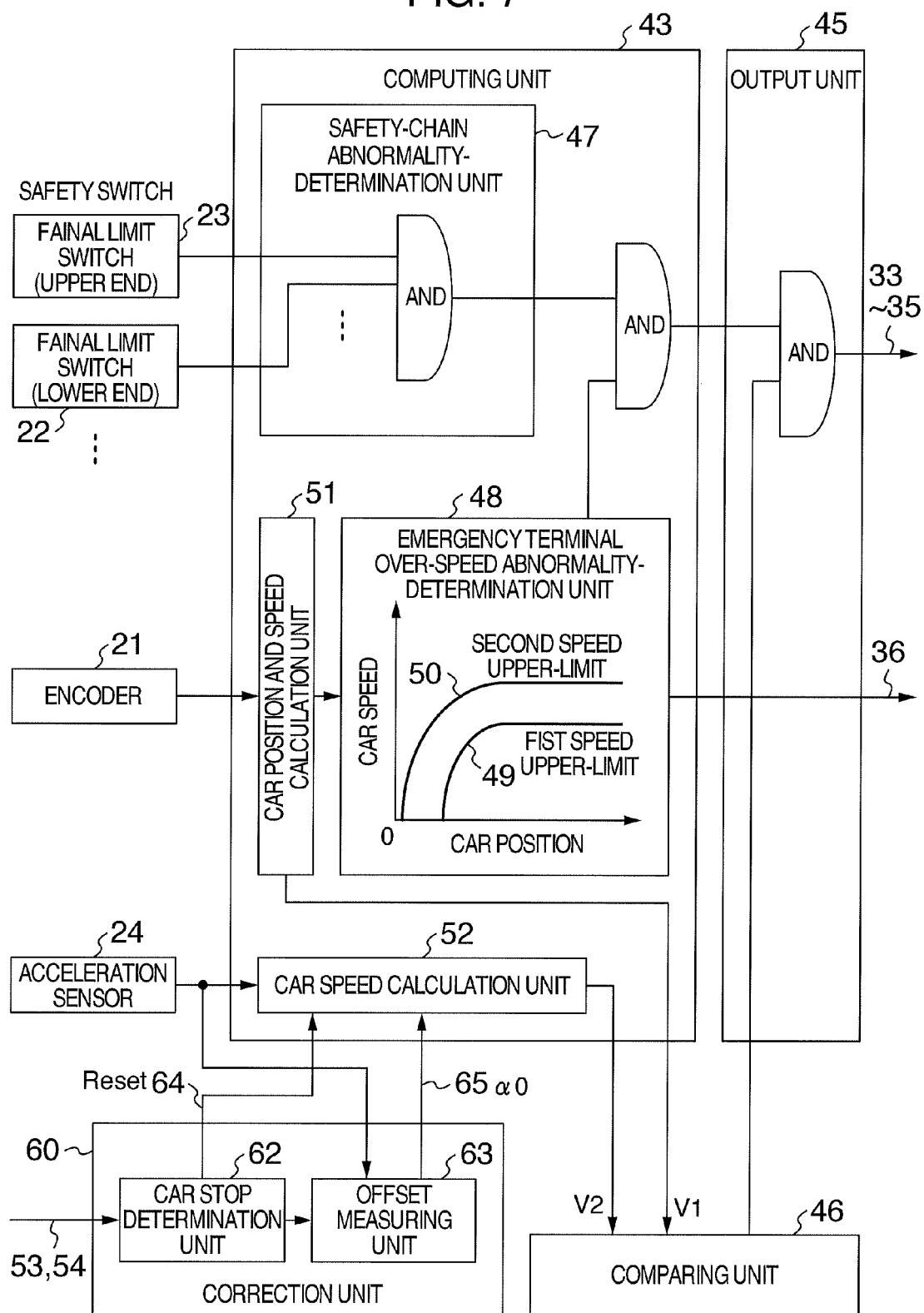


FIG. 8

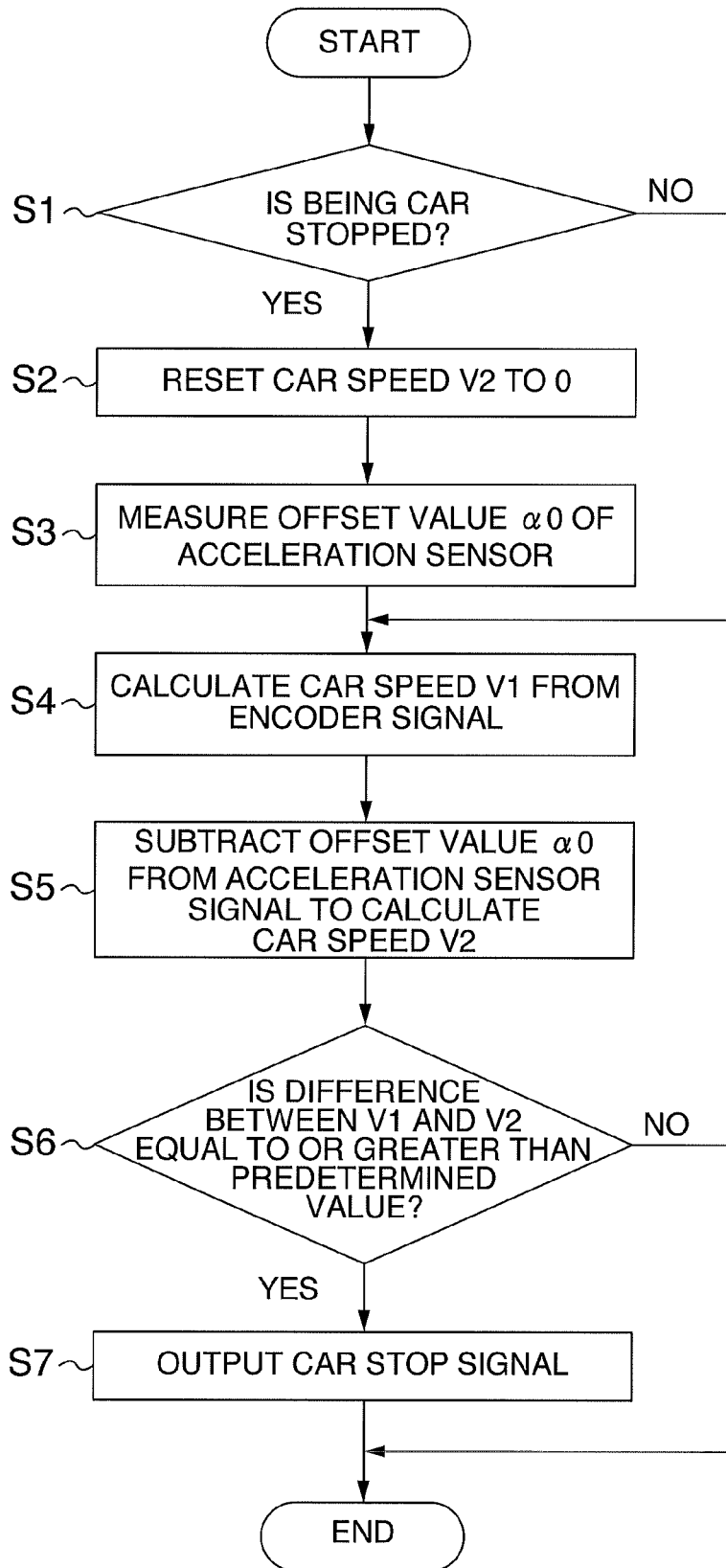
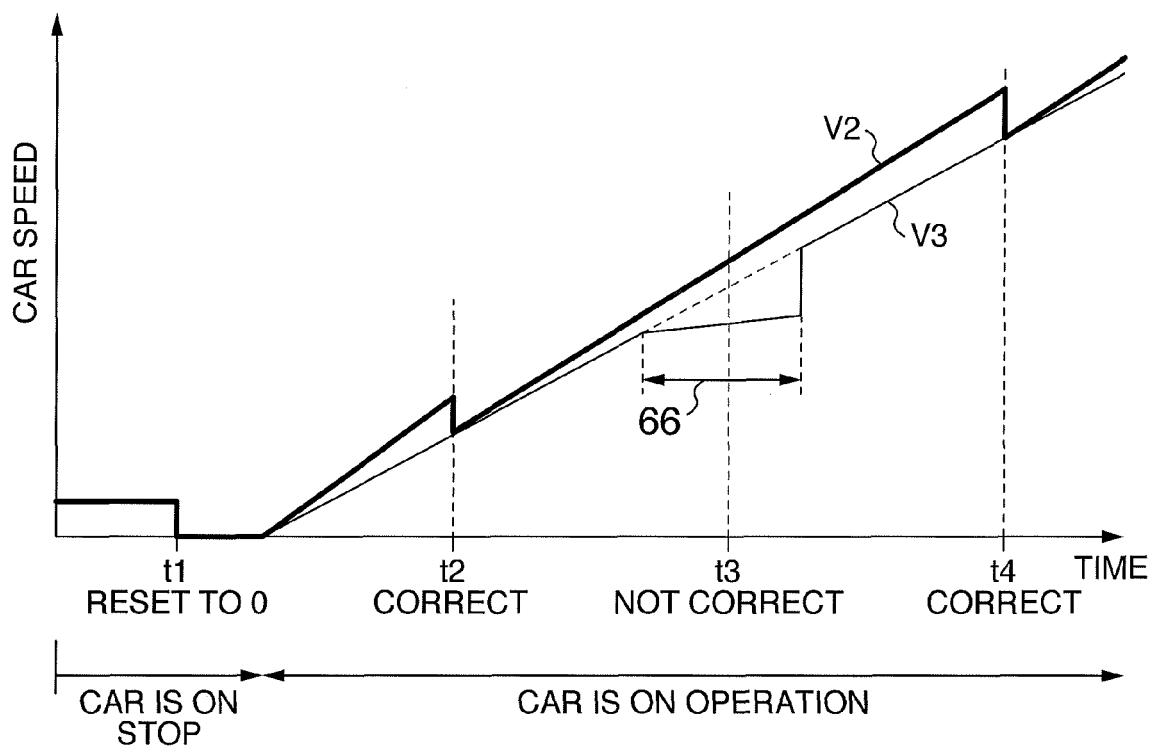


FIG. 9



**REFERENCES CITED IN THE DESCRIPTION**

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**Patent documents cited in the description**

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