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[Continued on next page]

(54) Title: A LIFT SYSTEM AND ITS CONTROL METHOD

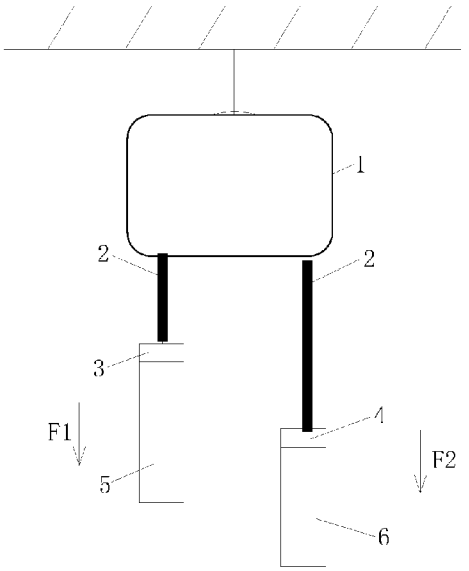


FIG. 1

(57) Abstract: A lift system and its control method, comprising a support point (1), a support body (2) positioned on the support point, a counterbalance end (4) connected with the counterweight (6), a carrier end (3) connected with the carrier (5), a counterbalance unit, a weight sensing unit measuring the weight of the carrier (5), a control unit, and an electric motor connected with the control unit to drive the carrier (5) upward and downward. The carrier end (3) and the counterbalance end (4) are disposed on the support body (2) and located on each opposite side of a support point. The control unit is in signal connection with the weight sensing unit and the counterbalance unit, and controls the counterbalance unit to select counterweight according to the measure results transferred from the weight sensing unit so that the weight or torque of the counterweight matches that of the carrier. Balance between the counterweight and the carrier can reduce energy consumption of motor, protect natural environment and save resources.

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Description

A LIFT SYSTEM AND ITS CONTROL METHOD

[1] FIELD OF INVENTION

[2] The present invention relates to a lift system driven by electric motor and its control method.

[3] BACKGROUND OF THE INVENTION

[4] With increase of productive forces, the use of electrical lift device is becoming more and more widespread. Electrical lift device driven by electrical motor moves the carrier upward and downward, and counterweight is always used to keep balance.

[5] But the widely-used electrical lift device has some shortcomings, for example, regardless of the load of the elevator, the counterweight is always the same. When the elevator car is moving upward, suppose the weight of elevator car is F1, the weight of counterweight is F2, in order to prevent sudden and fast moving upward caused by big weight difference (F1-F2), the electric motor needs to work along F1 direction and brake the movement of the elevator car; when the elevator car is moving upward and the carrier is weightier than the counterbalance, in order to avoid big weight difference (F1-F2), the electric motor needs to work along F2 direction and brake the movement of elevator car, otherwise the elevator car will not move upward; when passengers get off at Nth floor and other passengers wait at ground floor, the electric motor needs to work along F1 direction to bring the elevator car to ground floor; when the elevator car is moving downward and the carrier is lighter than the counterbalance, in order to avoid big weight difference (F2-F1), the electric motor needs to work along F1 direction and brake the movement of the elevator car, otherwise the elevator car will not move downward; when the elevator car is moving downward and the carrier is weightier than the counterbalance, in order to avoid sudden and fast moving downward caused by big weight difference (F1-F2), the electric motor needs to work along F1 direction and brake the movement of the elevator car; when passengers get off at ground floor and other passengers wait at Nth floor, the electric motor needs to work along F1 direction to bring the elevator car to Nth floor; Thus it is clear that the electric motor consumes additional energy to keep balance when elevator car moves up and down, which doesn't meet the requirements of environment protection.

[6] SUMMARY OF THE INVENTION

[7] The purpose of this invention is to provide an energy-saving lift system and its control method by removing the disadvantages presented above.

[8] In order to attain the above-mentioned object, the lift system of the present invention includes a support point, a support body positioned on the support point, a counterbalance end connected with the counterweight, a carrier end connected with carrier,

a counterbalance unit, a weight sensing unit measuring the weight of the carrier, a control unit, and an electric motor connected with the control unit to drive the carrier upward and downward. The carrier end and the counterbalance end are disposed on the support body and located on each opposite side of a support point. The control unit is in signal connection with the weight sensing unit and the counterbalance unit, and controls the weight of counterweight according to the measure results transferred from the weight sensing unit so that the weight or torque of the counterweight matches that of the carrier

[9] The lift system is an elevator, the support point is a pulley block, the carrier includes an elevator car, the elevator car and the counterweight connected with the carrier end and the counterbalance end respectively. The control unit can select counterweight to match the weight of carrier. The counterbalance unit selects suitable counterweight to match weight of carrier. Counterbalance unit comprises hooking and detaching actuator disposed at counterbalance end, a counterweight selector set on each floor, a conveyer device and at least two counterweights. The control unit controls the counterbalance unit to select counterweight that matches the weight of carrier according to measuring results transferred from weight sensing unit, and the selected counterweight then is conveyed to designated position. The hooking and detaching actuator can hook or detach counterweight. The Lift system is a lifting device, with the torque of counterweight or that of the carrier adjustable. At least two support points are included, each of support point matching different arm force of the counterweight or the carrier.

[10] The control method of a lift system, wherein lift system comprising: a support point, a support body, a counterbalance end connected with counterweight, a carrier end connected with an elevator car, and an electric motor. The Support body is located on the support point, the counterbalance end and the carrier end are disposed on the support body and located on each opposite side of support point, and the electric motor drives the elevator car upward and downward, and wherein the control method includes the following steps: a) Measuring the weight of the carrier; b) Selecting suitable counterweight based on the measuring step so that the weight or torque of the counterweight matches that of the carrier.

[11] The lift system is an elevator, wherein suitable counterweight is selected based on the measuring step so that the weight of the counterweight matches that of the carrier in step b), and wherein the counterbalance unit adjusts the length of force arm or the weight of counterweight to keep the torque of the counterweight and that of the carrier matched in step b).

[12] The benefit of this invention is to reduce energy consumption of the motor in the movement of the elevator car with the counterbalance unit to keep balance between the weight or torque of the counterweight and that of the carrier, therefore meet the re-

quirements of environment protection.

[13] BRIEF DESCRIPTION OF THE DRAWINGS

[14] FIG. 1 is a schematic drawing of an elevator;

[15] FIG. 2 is a structural drawing of an elevator;

[16] FIG. 3 is a structural drawing of counterbalance unit of an elevator;

[17] FIG. 4 is a schematic drawing of a mechanical crane-like device.

[18] DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[19] As shown in FIG1 to FIG3, an elevator system embodied in the present invention is generally designed for accommodating passengers or cargo, including elevator car 5, counterweight 6, cable 2, pulley block 1 and electric motor, elevator car 5 used for accommodating passengers or cargo, counterweight 6 used to keep balance of mass center during movement of elevator car 5, cable 2 for supporting the weight of the carrier end 3 and the counterbalance end 4. Pulley block 1 can be single fixed pulley or pulley system comprising one or more fixed pulley and moveable pulley, mechanical properties equivalently as single fixed pulley. Cable 2 is coupled to pulley block 1, the electric motor driving pulley block 1 to rotate to move the elevator car 5 upward and downward. Elevator car 5 is coupled to carrier end 3 of the cable, counterweight 6 coupled to counterbalance end 4 of the cable. The lift system in this invention also comprises weight sensing unit, control unit and counterbalance unit. The weight sensing unit is used to measure weight of elevator car and passengers or cargo (that is, weight sensing unit measures weight of carrier). The control unit is used to compute weight difference between the carrier and the counterweight to control rotation speed of the electric motor and control the counterbalance unit hooking or detaching a suitable counterweight. The counterbalance unit hooks or detaches a suitable counterweight according to signals transferred from the control unit. It either selects and hooks suitable counterweight on the counterbalance end, or detaches suitable counterweight from the counterbalance end and put it at any floor.

[20] The counterbalance unit comprises a hooking and detaching actuator disposed at the counterbalance end, a counterweight selector set on each floor, a conveyer device and at least two counterweights. The hooking and detaching actuator is an electromagnetic device. The counterweight selector selects suitable counterweight based on signal transferred from control unit, the selected counterweight then is conveyed by conveyer device to designated position, and the hooking and detaching actuator then hooks counterweight on counterbalance end. When detaching counterweight is required, the hooking and detaching actuator detaches counterweight from the counterbalance end, detached counterweight then is conveyed by the conveyer device to designated position.

[21] The control unit controls rotation speed, strength and rotation direction of the electric

motor. Electric motor's power and rotate direction changes according to weight changes of carrier and counterweight, control unit regulate power and rotate direction of electric motor by either controlling voltage or current or phase, depend on type of motor.

[22] The lift system of the present invention operates as follows:

[23] 1) Passengers get into elevator car, door close;

[24] 2) The weight sensing unit sends information to control unit after measuring weight of elevator car and passengers;

[25] 3) The control unit computes and decides weight of counterweight based on weight of the carrier, then sends signals to designated counterbalance unit, for example, the elevator stops at NO.A floor, top floor is M, then the required counterweight can be located at No. M-A floor;

[26] 4) The counterbalance unit selects and hooks suitable counterweight based on signal from control unit to minimize weight difference between carrier and counterweight;

[27] 5) The control unit controls the electric motor to drive the carrier car upward and downward

[28] In step 4), the least weight difference between carrier and counterweight is most preferable, and the ideal difference is zero (that is, the weight of counterweight equals that of carrier). As there are several counterweights available to be compared with that of the carrier at each floor, the counterweight with least difference is selected. Information of counterweights (numbers and weights) at each floor is stored in the control unit.

[29] Suppose the elevator moves from 6th floor to 8th floor in a 10-floor building, when passengers get into elevator car at 6th floor, the weight sensing unit measures the weight of the carrier and sends this information to the control unit, the control unit controls the operation of counterbalance unit located at 4th floor, the counterbalance unit detaches or hooks the suitable counterweight to reach the optimized model, and then the elevator car is driven to move.

[30] In this embodiment, cable 2 works as support body and coupled to pulley block 1, counterweight 6 and elevator car 5 are coupled to counterbalance end 4 and carrier end 3 of the cable respectively. The support body can be a chain, a conveyor belt, a pulley block or other structure that can be coupled with elevator car 5 as well as counterweight 6 and driven by the electric motor. The electric motor is disposed at either pulley block 1 or carrier end 3 or counterbalance end 4, or other position that can drive the elevator car to move.

[31] In Embodiments 2, an enclosed tank filled with fluid substance such as water, iron sand, is fixed on the counterbalance end; suitable counterweight can be obtained by injecting or emitting fluid substance. Injecting or emitting fluid substance can be

controlled by flow control device, such as flow regulating valve.

[32] In Embodiments 3, the hooking and detaching actuator disposed at the counterweight end can be a mechanical device, counterweight detached or hooked by this mechanical device.

[33] In Embodiments 4, counterweight includes fixed and adjustable weights, fixed counterweights settled on the counterbalance end and several adjustable counterweights available. Suitable adjustable counterweight is hooked on or detached from the counterbalance end based on signal from the control unit.

[34] Pulley block 1 can be a pulley system comprising fixed pulley and moveable pulley, mechanical properties equivalently as single fixed pulley. The pulley block works as a support point.

[35] The weight of counterweight is required to match that of carrier. For fixed counterweights, the one with least weight difference is selected; for adjustable counterweights, the one equal with that of carrier is selected. To ensure the stable movement of elevator car (for example, damping is considered when elevator is moving), the counterweight whose weight approaches that of the carrier is selected, and the weight difference may not be minimal. Pulley block can be a single pulley or pulley system comprising one or more fixed pulley and movable pulley, or other pulley-like structure that can move the elevator car. Information of counterweights (numbers and weights) at each floor is stored in the control unit.

[36] For elevator car, as the counterweight matches the weight of carrier, the energy consumption of motor is therefore reduced, which meets the requirements of natural environment protection.

[37] As show in FIG. 4, lift system is a mechanical lifting device that can be widely used at ports and factories. The lift system comprises support point O1 and support body 8. The carrier and counterweight are connected with carrier end 3 and counterbalance end 4 respectively, the carrier end connected to carrier 7 (for example, cargo to be handled at port), the counterbalance end connected to counterweight 6, making the system a level device. The middle part of the support body is mounted on support point O1, and the electric motor is coupled to the carrier via cable to move the carrier upward and downward. The force arm of carrier LA includes unchangeable fixed arm LA 1 and adjustable retractable arm LA 2, LA= LA 1 + LA 2. The force arm of counterweight LB includes unchangeable fixed arm LB 1 and adjustable retractable arm LB 2, LB =LB 1 +LB 2. The lift system also comprises weight sensing unit, control unit and counterbalance unit, which are in signal connection. The weight of counterbalance is F2, and the weight of carrier is F1.

[38] When the lift system conveys cargo, the weight sensing unit measures weight of carrier and feedbacks the information to control unit , the control unit controls the

counterbalance unit to select suitable counterweight by adjusting the torque of counterweight (F2×LB) equal with the torque of carrier (F1×LA). A power device adjusts length of retractable arm LB 2 of counterbalance horizontally to match that of carrier. Of course, this also can be achieved by adjusting length of retractable arm of carrier. The power device can be electric motor, hydraulic actuator, pneumatic actuator or other device that can adjust length of retractable arm based on electric signal.

[39] The support point also can be changed to adjust the torque, as show in FIG. 4, O1 or O2 (O3, O4 etc.) can be selected as support point to adjust the torque of the carrier approaching or equal to that of counterweight.

[40] Counterweight can be changed to adjust the torques, as described in description of elevator car.

[41] For the lifting mechanical device, as the difference between the torque of counterweight and that of carrier is minimal (that is, the torque of counterweight approaches or equals to that of carrier), the energy consumption of electric motor is reduced to protect natural environment and save resources.

[42] For the lift system, the counterbalance unit dynamically adjusts the counterweight by changing either the weight or the torque of counterweight relative to support point to keep the weight or the torque of counterweight and that of carrier matched. The word "match" means weight or torque of the counterweight equals or approaches that of carrier, or minimal difference between them.

[43] Although this invention has been shown and described with respect to exemplary embodiments thereof, it should be understood by those skilled in the art that the foregoing and various other changes, omissions, and additions in the form and detail thereof may be made therein without departing from the spirit and scope of the invention. Accordingly, the present invention has been described in several embodiments by way of illustration rather than limitation.

Claims

[1] 1. A lift system, comprising

a support point;

a support body positioned on the support point;

a counterbalance end connected with the counterweight;

a carrier end connected with the carrier, wherein said carrier end and said counterbalance end are disposed on the support body and located on each opposite side of a support point;

a counterbalance unit;

a weight sensing unit measuring the weight of the carrier;

a control unit in signal connection with said weight sensing unit and said counterbalance unit, and controlling said counterbalance unit to select counterweight according to the measure results transferred from said weight sensing unit so that the weight or torque of said counterweight matches that of said carrier;

and an electric motor connected with said control unit to drive the carrier upward and downward.

2. A lift system as claimed in claim 1, wherein said lift system is an elevator; wherein said support point is a pulley block; wherein said carrier includes an elevator car , said elevator car and said counterweight connected with said carrier end and said counterbalance end respectively; and wherein said control unit controls said counterbalance unit to select counterweight that matches the weight of carrier.

3. A lift system as claimed in claim 2, wherein said counterbalance unit selects counterweight that matches the weight of said carrier.

4. A lift system as claimed in claim 2, wherein said counterbalance unit comprising: a hooking and detaching actuator disposed on said counterbalance end, a counterweight selector set on each floor, a conveyer device and at least two counterweights, said control unit controls counterbalance unit to select counterweight that matches the weight of said carrier according to the measure results transferred from said weight sensing unit, the selected counterweight then be conveyed to designated position, said hooking and detaching actuator can hook or detach counterweight.

5. A lift system as claimed in claim 1, wherein said lift system is a lifting mechanical device, at least one force arm of said counterweight or said carrier adjustable.

6. A lift system as claimed in claim 5, wherein at least two said support points are included, each of said support point matching different force arm of said

counterweight or said carrier.

7. A control method of a lift system, wherein said lift system comprising: a support point, a support body, a counterbalance end connected with counterweight, a carrier end connected to an elevator car, and an electric motor; wherein said support body is located on the said support point, said counterbalance end and said carrier end disposed on said support body and located on each opposite side of said support point, said electric motor driving the carrier upward and downward; and wherein said control method includes the following steps:

a) Measuring the weight of said carrier;

b) Selecting suitable counterweight based on said measuring step so that the weight or torque of said counterweight matches that of said carrier.

8. A control method of a lift system as claimed in claim 7, wherein said lift system is an elevator, and wherein suitable counterweight is selected based on said measuring step so that the weight of said counterweight matches that of said carrier in said step b).

9. A control method of a lift system as claimed in claim 7, wherein said lift system is mechanical crane-like device, and wherein said counterbalance unit adjusts the length of force arm or the weight of counterweight to keep the torque of said counterweight and that of said carrier matched in said step b).

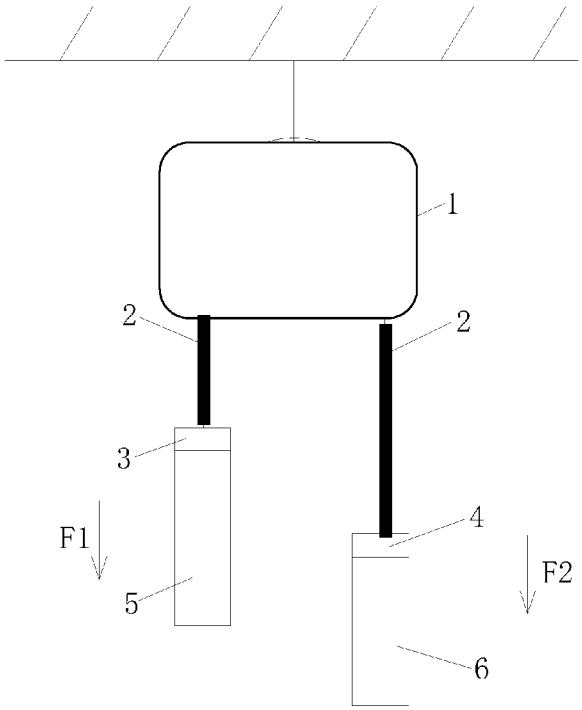

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2
2
3
F1
4
F2
5
6

FIG. 1

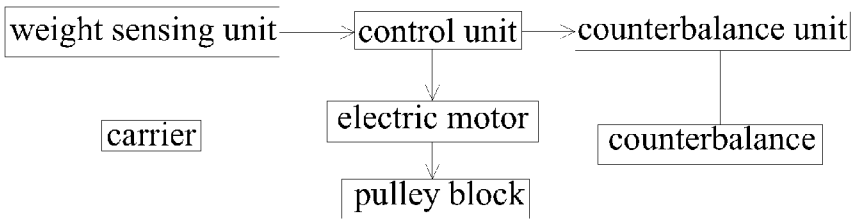

weight sensing unit
control unit
counterbalance unit
carrier
electric motor
counterbalance
pulley block

FIG. 2

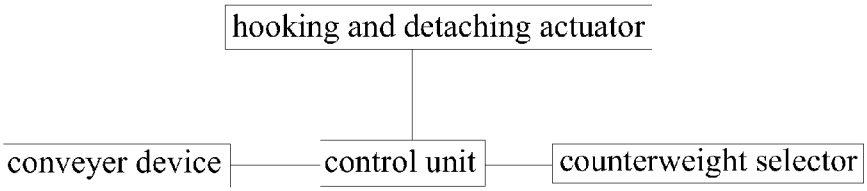

hooking and detaching actuator
conveyer device
control unit
counterweight selector

FIG. 3

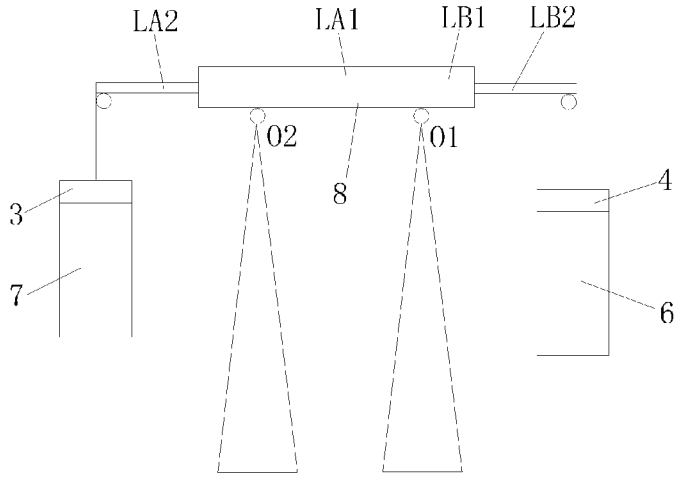

LA2
LA1
LB1
LB2
02
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8
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6

FIG. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2009/071509

A. CLASSIFICATION OF SUBJECT MATTER

See Extra Sheet

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: B66B, B66C

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPODOC, PAJ, WPI, CNPAT, CNKI: counterweight, counterbalance, balance, counter, moment

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN201214582Y (HITACHI ELEVATOR CHINA CO LTD) 01 Apr. 2009 (01.04.2009) See page 5, line 19 to page 7, line 7,figure 1	1-3,7,8
Y		5,6,9
X	CN2787626Y(SOUTHWEST PETROLEUM INST) 14 Jun. 2006 (14.06.2006) See Pages 4-5 of the description, figures 1,2,4	1-4
Y	GB2433734 A (SCHOFIELD DAVID) 04 Jul. 2007 (04.07.2007) See page 1 of the description, figures 1-3A of the drawings 1/9, and the drawings 3/9	5,6,9

☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:

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

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim (S) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
08 Dec.2009 (08.12.2009)	**24 Dec. 2009 (24.12.2009)**
Name and mailing address of the ISA/CN The State Intellectual Property Office, the P.R.China 6 Xitucheng Rd., Jimen Bridge, Haidian District, Beijing, China 100088 Facsimile No. 86-10-62019451	Authorized officer WANG, Yanqin Telephone No. (86-10)62085347

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2009/071509

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN201172566Y (HITACHI ELEVATOR CHINA CO LTD) 31 Dec. 2008 (31.12.2008) See figure 1 and its explanation	1-3,7,8
X	CN101195458A (HITACHI ELEVATOR CHINA CO LTD) 11 Jun. 2008 (11.06.2008) See page 3 of the description, paragraph 4, figures 1-4	1-3,7,8
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Y	GB2232651 A(VALUE CONTROL LIMITED) 19 Dec. 1990 (19.12.1990) See figures 1,2 and their explanations	5, 6, 9
Y	CN101049892 A (FUYOU CO LTD SHANDONG) 10 Oct. 2007 (10.10.2007) See figure 1 and its explanation	5, 6, 9

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2009/071509

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
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GB2232651 A	19.12.1990	None	
CN101049892 A	10.10.2007	None	

INTERNATIONAL SEARCH REPORT

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A. CLASSIFICATION OF SUBJECT MATTER

B66B1/02 (2006.01) i

B66B1/34 (2006.01) i

B66B11/08 (2006.01) i

B66C23/72 (2006.01) i