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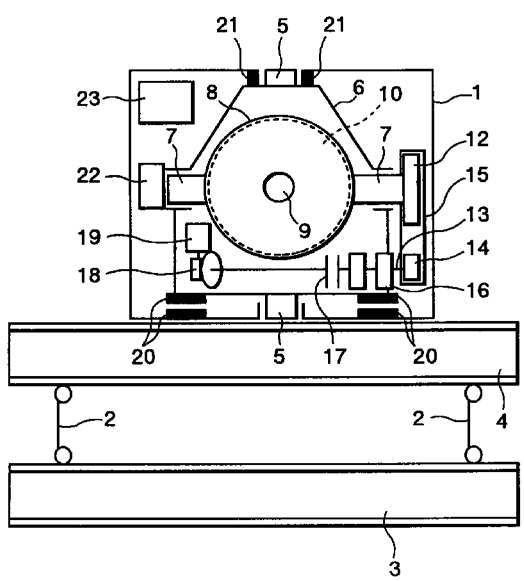
(54) Method and system for controlling attitude of lifting load utilizing gyro effect

(57) A lifting load attitude controlling system includes a lifting load pivoting clutch 20 provided between a gyro frame 1 and a gimbal frame 6 for connecting and disconnecting therebetween, and a resetting obliquely rotating clutch provided between a resetting oblique rotation driving portion constituted of a resetting oblique rotation driving motor 19 for obliquely rotating a gimbal 8 upon returning the gimbal 8 at a initial position and a warm gear, and the gimbal 8 for connecting and disconnecting therebetween. Upon obliquely rotating the gimbal for returning to the initial position, the resetting obliquely rotating clutch is placed in the engaged or connected state and the lifting load pivoting clutch is placed in the disengaged or disconnected state. When the resetting oblique rotation driving motor 19 is driven at this condition, a gyro moment which is generated upon obliquely driving the gimbal toward the gyro frame 1 (lifting jig 4) via a variable constant torque motor 19 between the gyro frame 1 and a gimbal frame 6. However, since the gyro moment is much smaller than the inertia moment of the lifting load to provide little influence for pivoting motion of the lifting load.

FIG.1



EP 0 802 150 A1

Description

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a method and a system for controlling attitude of a lifting load for appropriately pivoting a lifting load lifted by means of a wire rope or so forth. More specifically, the invention relates to a system which carries a gyro on a lifting jig for lifting the lifting load in horizontal attitude by means of the wire rope or so forth and obtaining a horizontal rotating force of the lifting jig in the horizontal direction utilizing a gyro effect.

Description of the Related Art

Conventionally, there are proposals for a crane with a rigid arm or rotary apparatus utilizing torsion of a rope as reacting force, for automating pivoting operation of a lifting load in a cargo operation. The former apparatus is excessively large in weight in relation to a lifting performance. The latter apparatus is unstable in pivoting behavor of lifting load. In place of these apparatus, there has been proposed a rotating attitude control system utilizing gyro effect (for example, Japanese Examined Patent Publication (Kokoku) No. Heisei 4-17873).

The rotating attitude controlling system for the lifting load disclosed in the above-identified publication is formed with a lifting jig which is hanged in horizontal attitude on a wire rope and mounting a lifting load at the lower portion thereof, a frame fixed on the lifting jig, and a case rotatable about a rotation axis parallel to an extending direction relative to the frame, and a flywheel capable of spinning shaft perpendicular to a surface including a rotation axis of the case. The case and the flywheel form a gimbal structure to form pseudo gyro scope together with the frame. Then, by detecting an angle of natural pivoting motion of the lifting load by external disturbance, such as wind and so forth, the lifting load is pivoted in the opposite direction in a magnitude corresponding to the natural rotation by driving the gymbal by a motor, while the natural rotation anagle is relatively small, for constantly maintaining predetermined azimuth angle.

On the other hand, in such rotating attitude controlling system of the lifting load utilizing the gyro effect, rotational position of the gimbal in repeated use of the system cannot be constant. Also, when external disturbance, such as wind or so forth, is exerted on the pivot axis of the lifting load (lifting jig), by rotating the gimbal for orienting a spinning shaft of the flywheel at substantially vertical direction, rotation due to external disturbance can be restricted. However, it may maintain oblique position due to shifting of the offset position by rotation of gimbal.

Here, the offset position is the rotational position of the gimbal when the driving motor of the gimbal is not actuated and the gimbal is not locked.

Subsequently, when the gimbal is rotated to a initial position (hereinafter simply referred to as "initial position") to orient the spinning shaft, rotation in the direction of external disturbance is accelerated. While such pre-session force is convenient if pivots the lifting load in the same direction to the rotating direction by the external disturbance, when a rotational force in opposite direction is to be applied, it becomes necessary to return to the initial position by tilting the gimbal to exert the pivoting force on the lifting load in the same direction to the rotating direction by the external disturbance.

On the other hand, when driving of the motor for rotating the gimbal is terminated, a component of accelerating rotation can be canceled by rotating the gimbal. Therefore, it is not possible to return the gimbal to the initial position simply by rotating the gimbal in the opposite direction.

As set forth above, it is required substantial skill for returning the gimbal from the rotated position to the initial position. Furthermore, since the operator is often stay away from the system, resetting operation by the operator alone is further difficult.

SUMMARY OF THE INVENTION

The present invention is worked out in view of the problems in the prior art. Therefore, it is an object of the present invention to provide a method and system for controlling a lifting load which can easily return a gimbal which is rotated by external disturbance, to a initial position utilizing a gyro effect without influencing pivoting motion of the lifting load.

In order to accomplish the above-mentioned object, according to the first aspect of the invention, a lifting load attitude control system utilizing a gyro effect, comprises:

a lifting jig to be hanged in horizontal attitude for hanging a lifting load;

a gyro frame fixed to the lifting jig;

a gimbal frame rotatable about a rotating axis perpendicular to a gimbal frame;

a gimbal rotatable about a rotation shaft extending perpendicular to a surface including the rotating axis of the gimbal frame, with respect to the gimbal frame;

a flywheel capable of spinning about a spinning shaft perpendicular to a surface including the rotation shaft with respect to the gimbal;

a rotational driving portion mounted on the gimbal frame and driving the gimbal in forward and reverse direction;

a spinning driving portion mounted on the gimbal and spinning the flywheel;

a lifting load pivoting clutch for making the gyro frame and the gimbal frame releasable; and

a mechanism for canceling a reaction torque to be exerted on the rotational driving portion from the gimbal frame.

In the construction set forth above, under the normal rotating operation, the lifting load pivoting clutch is placed in engaged or connected position. By driving the spinning driving portion and the rotational driving portion at this condition, rotation and stopping of pivoting motion of the lifting load is performed.

When external disturbance, such as wind or so forth is exerted on the lifting load for causing pivoting motion about the pivoting axis, the gimbal is rotated to place the spinning shaft of the flywheel at the orientation close to vertical depending upon the magnitude of the externally applied disturbing force. Thereafter, when the gimbal is returned to the initial position, the lifting load pivoting clutch is placed in disengaged condition and the rotational driving portion is driven in reverse direction. Then, the gimbal rotates obliquely. At this time, since the flywheel is held rotating, gyro effect is caused to rotation of the gimbal frame in the same direction. However, since the gimbal frame and the gyro frame (lifting jig) are spaced away from each other, the gimbal may solely rotated without influencing to the gyro frame. Accordingly, the gimbal may be returned to the initial position without exerting pivoting force to the lifting load in the same direction.

It should be noted that when the switch of the rotational driving portion is turned OFF when the gimbal frame returns to the initial position, inertia force is exerted on the gimbal frame for further rotation to cause opposite gyro effect to act a force (torque) to obliquely rotate the gimbal in the direction way from the initial position on the rotational driving portion. However, since the mechanism for canceling the reaction torque is provided, the gimbal can be maintained at the initial position.

According to the second aspect of the invention, the lifting load attitude control system may further comprise:

a resetting oblique rotation driving portion for obliquely rotating the gimbal upon returning the gimbal at initial position;
a warm gear mechanism connected to the resetting oblique rotation driving portion;
a resetting obliquely rotating clutch provided between the warm gear mechanism and the gimbal or the rotational driving portion and making them releasable; and
control means for controlling pivoting motion of the lifting load hanged on the lifting jig by controlling driving of the spinning driving portion, the rotational driving portion, and engagement and disengagement of the lifting load pivoting clutch and the resetting obliquely rotating clutch.

In the normal rotating operation, in addition to maintaining of the lifting load pivoting clutch in the engaged condition, the resetting obliquely rotating clutch is placed in the disengaged position. Upon oblique rotation for returning the gimbal to the initial position, the resetting obliquely rotating clutch is placed in engaged position and the lifting load pivoting clutch is placed in disengaged position. When the resetting oblique rotation driving portion is driven at this position, similarly to the first aspect of the invention, the gimbal may be rotated without exerting pivoting force for the lifting load.

According to the third aspect of the invention, the lifting load attitude control system may further comprise a variable constant torque transmitting device provided between the gyro frame and the gimbal frame.

Upon obliquely rotating the gimbal to return to the initial position, the gimbal frame is rotated by gyro effect. Then, only relatively small torque set by the variable constant torque transmission device is transmitted to the gyro frame. The gimbal can be quickly returned to the initial position with little influence for gyro frame and thus the lifting jig (lifting load). At this time, As a reaction field of the inertia moment of the lifting load, small transmission torque between the gyro frame and the gimbal frame serves as a force for braking rotation of the gimbal frame.

According to the fourth aspect of the invention, a method for controlling pivoting motion of a lifting load hanged by a lifting jig employing a lifting load attitude control system as set forth above, comprises the steps of:

placing the lifting load pivoting clutch in engaged condition, placing the resetting obliquely rotating clutch in disengaged condition and driving the spinning driving portion and the rotational driving portion during normal rotating operation; and
placing the resetting obliquely rotating clutch in engaged condition, placing the lifting load pivoting clutch in disengaged condition and driving the resetting oblique rotation driving portion upon returning the gimbal to the initial position.

According to the fifth aspect of the invention, a lifting load attitude control system utilizing a gyro effect, comprises:

a lifting jig to be hanged in horizontal attitude for hanging a lifting load;
a gyro frame fixed to the lifting jig;
a gimbal frame rotatable about a rotating axis perpendicular to a gimbal frame;
a gimbal rotatable about a rotation axis extending perpendicular to a surface including the rotating axis of the gimbal frame, with respect to the gimbal frame;
a flywheel capable of spinning about a spinning shaft perpendicular to a surface including the rotation axis with respect to the gimbal;
a rotational driving portion mounted on the gimbal frame and driving the gimbal in forward and reverse direction;
a spinning driving portion mounted on the gimbal

and spinning the flywheel;

a rotational position detecting sensor for detecting a rotational position of the gimbal;

the rotational driving portion controlling rotation of the gimbal from the rotational position toward initial position on the basis of the output if the rotational position detecting sensor; and

braking means for stopping the rotational driving portion when the rotational position of the gimbal substantially match with the initial position.

With such system, on the basis of the rotational position signal from the rotational position detecting sensor, a sequence of control for resetting the gimbal at the initial position by controlling rotation of the gimbal. experience and qualification is not required to reset gimbal in operation by one operator.

According to the sixth aspect of the invention, a method for controlling pivoting motion of a lifting load hanged on a lifting jig employing a lifting load attitude control system utilizing a gyro effect as set forth above, comprises the steps of:

fixing the lifting jig or the lifting load on a stationary portion to make prohibiting them from rotation irrespective of forced rotation of the gimbal;

subsequently rotating the gimbal by the rotational driving portion for returning to the initial position.

In this method, when the lifting load is lifted under the condition where the flywheel is driven for spinning in the predetermined direction at high speed to forcedly vary the attitude of the lifting load, the gimbal is forcedly rotated by the rotational driving portion to cause the gyro effect to rotate the lifting jig (lifting load) in the direction not being obstructed by the weight component of the lifting load.

On the other hand, in order to stop rotation as forcedly rotated, by shutting off power supply for the driving motor to cause the pivoting inertia moment of the lifting load to be exerted on the gimbal to generate the gyro moment by the gyro effect for obstructing pivoting motion of the lifting load to stop rotation.

When the system subjects external disturbance, such as wind to cause rotation of the gimbal to shift the offset position, or in the alternative when the gimbal is to be placed at the initial position, the lifting jig or the lifting load is placed at the fixing portion, such as the construction, ground or so forth, or fixed by other means so as not to pivot irrespective of rotation of the gimbal. Thereafter, on the basis of the rotational position o the gimbal detected by the rotational position detecting sensor, the gimbal is rotated in the direction requiring smaller rotational magnitude to reach the initial position. Upon detection of reaching at the position close to the initial position, the gimbal is locked. By this, the gimbal may be reset at the initial position with releasing the gyro effect, lifting operation for the lifting load requiring pivoting of the lifting load can be continuously performed.

According to the seventh aspect of the invention, a lifting load attitude control system utilizing a gyro effect, comprising:

a lifting jig handed in horizontal attitude for hanging a lifting load;

a gyro frame fixed to a lifting jig;

a gimbal frame rotatable about a rotation axis perpendicular to the gyro frame;

a gimbal rotatable about a rotation axis perpendicular to a surface including the rotation axis of the gimbal frame, relative to the gimbal frame;

a flywheel capable of spinning about a spinning shaft perpendicular to the surface including the rotation axis;

a rotational driving portion for rotating the gimbal mounted on the gimbal frame in the forward and reverse direction;

a spinning driving portion for spinning the flywheel mounted on the gimbal;

a rotational position detecting sensor for detecting a rotational position of the gimbal;

air ejecting means for generating a moment about a rotation shaft on the lifting jig for rotating the later from the rotational position of the gimbal to an initial position by reaction associating with air ejection on the basis of the output of the rotational position detecting sensor; and

braking means for stopping the rotational driving portion when the rotational position of the gimbal substantially match with the initial position.

BRIEF DESCRIPTION OF THE DRAWINGS

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

In the drawings:

Fig. 1 is a front elevation showing an overall construction of one embodiment of a lifting load attitude controlling system utilizing a gyro effect, according to the present invention;

Fig. 2 is an explanatory illustration showing a mechanism for canceling a reaction torque;

Fig. 3 is a partially sectioned front elevation of another embodiment of the lifting load attitude controlling system utilizing the gyro effect, according to the invention;

Fig. 4 is a partially sectioned side elevation of the system of Fig. 3;

Fig. 5 is a perspective view showing a further embodiment of the method and system for controlling attitude of the lifting load according to the present invention; and

Fig. 6 is a perspective view showing a still further embodiment of the lifting load attitude control system employing a gyro effect, according to the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The present invention will be discussed in detail in terms of the preferred embodiment, 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 unnecessary obscure the present invention.

Figs. 1 and 2 show a lifting load attitude controlling system utilizing a gyro effect according to the present invention. The shown lifting load attitude controlling system includes a box shaped gyro frame 1 hanged by a crane (not shown), a lifting jig 4 formed with wide flange beam or H steel for hanging down a lifting load 3 (wide flange beam in the shown case) with hanging ropes 2, 2 fixedly integrated in the horizontal condition on the bottom portion of the gyro frame 1, a gimbal frame 6 rotatable about a vertical rotation axis 5 within the gyro frame 1, a gimbal 8 rotatable about a rotation shaft 7 with respect to the gimbal frame 6, and a flywheel 10 which can spin about a spinning shaft 9 with respect to the gimbal 8.

The gimbal 8 is rotatable at appropriate speed in forward and reverse directions about the rotation axis 7 (axis parallel to the lifting jig 4) perpendicular to a surface including a rotation axis 5 of the gimbal frame 6 by means of a gimbal driving motor 11 (rotary driving portion) mounted on the gimbal frame 6. On the other hand, the flywheel 10 can spin at high speed about the spinning shaft 9 perpendicular to the surface including the rotation shaft 7 of the gimbal 8 by a not shown spinning motor (spin driving portion) mounted on the gimbal. The gimbal driving motor 11 and the spinning motor are electromagnetic motors driving for rotation and spinning of the rotation shaft 7 and the spinning shaft 9 in non-contact state, respectively.

Further concrete discussion will be given for rotation mechanism of the gimbal 8. Namely, a driven pulley 12 is connected to one end of the rotation shaft 7 of the gimbal 8. A driving pulley 14 is connected to one end of a rotary driving shaft 13 arranged in parallel to the rotation shaft 7. Between both pulleys 12 and 14, a timing belt 15 is wound around. At the intermediate portion of the rotary driving shaft 13, a rotational driving force of the gimbal driving motor 11 is transmitted to the rotary driving shaft 13 via a helical gear box 16.

Furthermore, the other end of the rotary driving shaft 13 is releasably connected to a resetting obliquely rotating motor 19 (resetting obliquely rotating driving portion) via a resetting obliquely rotating clutch 17 (electromagnetic clutch) and a speed reduction mechanism 18. The gimbal driving motor 11 can drive to rotate the rotary driving shaft 13 in forward and reverse directions in non-contact condition. A warm gear mechanism 18 has non-reversible characteristics for permitting transmission of a driving force from the setting obliquely rotating motor 19 to the rotary driving shaft 13 but prohibiting transmission of driving force from the rotary driving shaft 13 to the resetting oblique rotating motor 19.

The resetting obliquely rotating clutch 17 is placed in released condition, the rotational driving force of the gimbal driving motor 11 is transmitted to the rotating driving shaft 13 and then transmitted to the rotation shaft 7 of the gimbal 8 via the driving pulley 14, the timing belt 15 and driven pulley 12 in order. On the other hand, when the resetting obliquely rotating clutch 17 is placed in engaged condition, obliquely rotating driving force of the resetting obliquely rotating motor 19 is transmitted to the rotary driving shaft 13 and then transmitted to the rotation shaft 7 of the gimbal 8. Accordingly, the gimbal driving motor 11 drives the gimbal 8 in forward and reverse directions, whereas the resetting obliquely rotating motor 19 is adapted to drive the gimbal obliquely upon returning to the initial position.

It should be noted that the resetting obliquely rotating clutch may be directly connected to the gimbal via the driven pulley 12 instead of connecting to the resetting obliquely rotating motor 19.

Also, between the bottom surface of the gyro frame 1 and the upper surface of the bottom portion of the gimbal frame 6, a lifting road rotating clutch 20 for contacting and releasing the surfaces. The lifting load pivoting clutch 20 is placed in connecting condition, the gimbal frame 6 rotates integrally with the gyro frame 1, namely the lifting jig 4 (lifting load 3). On the other hand, when the lifting load pivoting clutch 20 is released, even when rotation of the gimbal 8 is transmitted to the gimbal frame 6, the transmitted rotation force will never influence to the lifting jig 4 (lifting load).

Between the lower surface of a ceiling portion of the gyro frame 1 and the upper surface of the ceiling portion of the gimbal frame 6, a variable constant torque transmitting device 21 is provided. The variable constant torque transmitting device 21 is adapted to transmit only torque preliminarily set to be smaller among rotating forces of the gimbal frame 6.

The gimbal frame 6, the gimbal 8, the flywheel 10 and so forth form a gyro. It should be noted that, at the position of other end of the rotation shaft 7 of the gimbal, a n oblique rotation detector 22 for detecting obliquely rotating condition of the gimbal, is provided. Within the gyro frame 1, a control unit 23 and so forth controlling the gyro, the oblique rotation detector 22 and so forth control rotational driving of the gimbal driving motor 11, the spinning motor and the resetting obliquely rotating motor 19, and controlling rotational driving of the resetting oblique rotation clutch 17, the lifting load pivoting clutch 20 for contacting and releasing.

Next, operation will be discussed.

Upon normal rotating operation, the lifting load pivoting clutch 20 is placed in connected condition and the resetting obliquely rotating clutch 17 is placed in disconnected or released condition. At this condition, the spinning driving motor and the gimbal driving motor 11 are driven to rotatingly drive the gimbal for generating gyro effect to cause rotation of the lifting load 3 via the gimbal frame 6, the gyro frame 1 and the lifting jig 4. On the other hand, when rotational driving of the gimbal 8 is stopped, the gimbal 8 is driven to rotate by rotational force of the lifting load 3. By the gyro effect thus generated, the pivoting force of the lifting load 3 can be canceled to stop pivoting motion of the lifting load 3.

When external disturbance, such as wind and so forth is exerted on the lifting load 3, the gimbal 8 is rotated to orient spinning shaft 9 of the flywheel 10 at an angle close to vertical depending upon the force of external disturbance. Subsequently, upon obliquely driving the gimbal to return to the initial position, the resetting obliquely rotating clutch 17 is placed in the connected condition and the lifting load pivoting clutch 20 is placed in released condition. At this condition, when the resetting obliquely rotating motor 19 is driven, the gimbal 8 is obliquely rotated via the warm gear mechanism 18 and the rotatingly driving shaft 13. When the gimbal frame 6 is driven to obliquely rotate in the resetting direction, the gimbal frame 6 is rotated in the same direction to the external disturbance by the gyro effect. At this time, since the gyro frame 6 (lifting jig 4) and the gimbal frame 6 are placed in released condition, the rotational force of the gimbal 6 by gyro effect is not transmitted to the gyro frame 1. Accordingly, the rotational force is not transmitted to the lifting jig 4.

It should be noted that the resetting obliquely rotating motor 19 is connected to the warm gear mechanism having non-reversible characteristics, anti-gyro moment due to inertia moment of the gimbal frame 6 can be dumped. Accordingly, by applying large torque at low rotation speed for the gimbal, the gimbal frame 6 is rotated by the gyro moment. The rotational force to be transmitted to the gyro frame 1 acts on the variable constant torque transmitting device 21 to be only smaller rotational torque. Thus, the transmitted rotation force may give little influence to the gyro frame 1.

Furthermore, if acceleration and deceleration control, such as speed control for accelerating zone, constant speed zone and decelerating zone or so forth, is performed upon obliquely rotating the gimbal frame 6, operations of the variable constant torque transmission device 21 and the warm gear mechanism 18 may be caused depending upon oblique rotation speed and torge of the gimbal and pivoting speed of the gimbal frame 6, in chained manner so as to position of the gimbal at the predetermined position without significantly influencing for pivoting motion of the lifting load 3, and to control braking for the gimbal frame 6.

While the foregoing dicsussion has been given for the case where the dedicated resetting obliquely rotating motor 19 is employed, it should be possible to reset the gimbal driving motor 11 without employing such dedicated motor.

In such case, it becomes necessary to provide a mechanism for canceling the reaction torque, as set forth above. As such mechanism,

① the gimbal driving motor 11 is constructed with a motor 11A with a brake (Fig. 2a);

② an electromagnetic brake 24 a is provided on a transmission shaft between the gimbal driving motor 11 (rotatingly driving portion) and the gimbal (Fig. 2b);

③ A ratchet mechanism is provided on the transmission shaft between the gimbal driving motor 11 and the gimbal for selective engagement of the claw of the rachet (Fig. 2c).

Next, discussion will be given for another embodiment of the method and system for controlling attitude of the lifting load according to the present invention. In the shown embodiment, the gyro frame 1 is fixed on the lower portion of the lifting jig 4 in depending condition. On the other hand, the spinning shaft 9 of the flywheel 10 is located at lower side of the rotation shaft 7 of the gimbal 8. A stopper 30 is provided at inner side portion of the gyro frame 1 for restricting range of rotation of the gimbal 8. Furthermore, in order to detect rotational position of the rotation shaft 7, the rotational position detecting sensor 31 is provided on the outer side of the gyro frame 1.

As the rotational position detecting sensor 31, various sensors, such as those combined with an encoder, a potentiometer or limit switch, those combined with a photosensor or so forth may be employed. On the other hand, while a rotational position detecting sensor 31 is essential in the shown embodiment, it is not essential to fixedly secure the gyro frame 1 in dependent manner, to provide the stopper 30, and to position the spinning shaft 9 at lower side of the rotation shaft 7.

Then, when the external disturbance, such as wind or so forth acts on the lifting load during lifting operation, the offset position of the gimbal 8 is significantly displaced in the extent corresponding to the external disturbing component, and thus balance is significantly destroyed in rotational performance in certain rotational direction, the lifting jig 4 or lifting load 3 is placed on the ground or stationary portion of the construction to make impossible to pivot the lifting load irrespective of rotation of the gimbal 8. Next, on the basis of the rotational position detected by the gimbal rotational position detecting sensor 31, the gimbal driving motor 11 is driven in the direction requiring smaller rotational magnitude to the initial position. When the rotational position detecting sensor 31 detects the gimbal 8 reaching the rotational position in the vicinity of the initial position, driving of the motor 11 is stopped to stop rotation of the gimbal 8. At the same time, by locking the gimbal 8, correction of the offset position or resetting of the gimbal can be performed in the condition where gyro effect is released.

On the other hand, within the control unit 23, a radio apparatus for transmitting and receiving an operation signal from remote position is provided. The operator performs ratio operation through an operating radio apparatus in hand with visually operating rotational attitude of the lifting load 3. The operator can be plural and the operating position can be a plurality of separated positions. When a plurality of operating radio apparatus are employed, it is desirable to set preference of operation for assuring security.

It should be noted that the reference numeral 33 denotes a power source unit, in which a power source battery and a battery charger are provided. When a power source is supplied externally, a power source converter may be provided.

Fig. 5 shows a further embodiment of the method and system for controlling attitude of the lifting load according to the present invention. In the shown embodiment, a plurality of rotation control systems are employed for one lifting load 3. Then, any one of the radio apparatus is taken as a master. Also, a cable connector 34 is provide for making the signal thereof in common to other radio apparatus. By connecting a plurality of rotation control systems by a cable 35 via the cable connectors 34, respective rotation control apparatus can be synchronized with each other. It should be noted that the gyro frame 1 is fixed on the lifting jig so that the weight of the lifting load 3 and the lifting weight of the lifting equipment will not be exerted directly on the gyro frame 1.

As shown in Fig. 5, when a plurality of rotating systems are arranged along a direction of the rotation shaft (vertical direction), rotational vector axis for rotation can be placed coaxially, or in quite close to the common axis. Therefore, rotational force double or triple of gyro effect can be obtained depending upon efficiency and number of the rotating systems. When a plurality of rotating systems are provided, they may be placed at upper and lower sides of the lifting jig 4.

Fig. 6 shows the still further embodiment of the lifting load attitude control system employing a gyro effect, according to the present invention. In the shown embodiment, an air ejection means 40 are provided at both ends of a lifting jig 4. By reacting force associating with ejection of air from the air ejection means 40, the gimbal 8 displaced from the offset position is returned to the initial position.

In the inner bottom portion of the gyro frame 1, an air compressor 41 is provided. A compressed air generated by the air compressor 41 is accumulated in a cylindrical air receiver tank 43 provided at the outer portion of the gyro frame 1 via a first flexible hose 42. To the air receiver tank 43, one end of a second flexible hose 44 is connected. The other end of the second flexible hose 44 is connected to respective air ejection means 44.

Each of air ejection means 40 is provided with an electromagnetic opening and closing valve 45 is connected to the second flexible hose 44. In the electromagnetic opening and closing valve 45, an air ejection nozzle 46 extending in horizontal direction perpendicular to longitudinal direction of the lifting jig 4, and an air ejection nozzle 47 extending in horizontally outside long the longitudinal direction of the lifting jig 4 are connected. Then, by controlling opening and closing the electromagnetic opening and closing valve 45, the compressed air is selectively ejected from respective nozzles 46 and 47.

As viewed the lifting jig 4 from the upper side, the nozzle 46 ejects air foward tangent direction of a horizontal circle having a diameter of the lifting jig 4. By selectively ejecting air in the air ejecting means 40, the lifting jig 4 is rotated in the direction opposite to the air ejecting direction, or in the alternative, is shifted in parallel in the direction perpendicular to the longitudinal direction of the lifting jig. Furthermore, by arbitrarily combining nozzles 46 and 47 ejecting air, the lifting jig 4 can be shifted in the direction toward which a composite propelling force by reaction of air ejection is directed.

It should be noted that the air ejection means 40 is arranged at the same distance from the rotational axis in the lifting jig, in order to cause the foregoing effect.

Here, the electromagnetic opening and closing valve 45 is desirable to intermittently eject air from the nozzles 46 and 47 by opening and closing the valve in quire short cycle. This is because influence of the pressure loss at the intermediate position of the pressurized air supply path (particularly to the second flexible hose 44) is little and thus high pressure and high speed air ejection can be obtained.

On the other hand, in the shown embodiment, the rotational position detecting sensor 30 for detecting rotational position of the gimbal is provided similarly to the second embodiment. In addition, a brake device 48 for braking rotation of the rotation shaft 7 of the gimbal is provided outside of the gyro frame 1, and a free rotation control device 48 for electrically controlling free rotation of the rotation shaft 7 are provided. The free rotation control device 49 is a known device for preventing the rotation shaft 7 from rotation in the forward or reverse direction or for preventing the rotation shaft 7 from rotating in any of the forward and reverse directions for disabling free rotation.

When the lifting load 3 is subject external disturbance, such as wind or so forth, during lifting operation, and thus the gimbal is significantly displaced from the offset position in the extent corresponding to the magnitude of absorbed external disturbance, or upon restrating, the gimbal is returned to the initial position in the following manner.

<u>Initialization Without Hanging Lifting Load</u>

At first, after placing the gimbal in a state for free rotation, on the basis of the rotational position detected by the gimbal rotational position detecting sensor 30, air is ejected from respective nozzles 46 located at both ends of the lifting jig 4 to cause rotation of the gimbal 8 toward the initial position. Then, a force couple for causing rotation of the lifting jig is generated to cause rotation of the gimbal by gyro effect. At a timing where the rotational position detecting sensor 30 detects the rotational position of the gimbal 8 reaching in the vicinity of the initial position, air ejection is terminated to stop rotation of the gimbal. Simultaneously, the gimbal 8 is locked in place by the brake device 48. Thus, without fixing the lifting jig 4 or the lifting load 3 on the ground as in the former embodiment, correction of the offset position or resetting to the initial position of the gimbal can be performed in the condition where the gyro effect is released.

Initialization With Hanging Lifting Load

When the rotational force by ejection of air from the nozzles 46 is applied to the lifting jig 3, as set forth above under the condition where the lifting load is hanged, the inertia force of the lifting load and spring function of the hanging rope disposed between the lifting jig 4 and the lifting load 3, it is possible to cause simple harmonic motion with a phase difference between the lifting jig 4 and the lifting load 3. At this time, by restricting rotational direction in one direction by the gyro effect by the free rotation control device 49, the gimbal 8 can be rotated to the initial position, intermittently. It should be noted that the free rotation control device 49 is applicable for the case where the gimbal 8 is returned to the initial position under the condition where the lifting load is not hanged.

Although the invention has been illustrated and described with respect to exemplary embodiment thereof, it should be understood by those skilled in the art that the foregoing and various other changes, omissions and additions may be made therein and thereto, without departing from the spirit and scope of the present invention. Therefore, the present invention should not be understood as limited to the specific embodiment set out above but to include all possible embodiments which can be embodies within a scope encompassed and equivalents thereof with respect to the feature set out in the appended claims.

Claims

1. A lifting load attitude control system utilizing a gyro effect, comprising:

   a lifting jig to be hanged in horizontal attitude for hanging a lifting load;
   a gyro frame fixed to said lifting jig;
   a gimbal frame rotatable about a rotating shaft perpendicular to a gimbal frame;
   a gimbal rotatable about a rotation shaft extending perpendicular to a surface including said rotating shaft of said gimbal frame, with respect to said gimbal frame;
   a flywheel capable of spinning about a spinning shaft perpendicular to a surface including said rotation shaft with respect to said gimbal;
   a rotational driving portion mounted on said gimbal frame and driving said gimbal in forward and reverse direction;
   a spinning driving portion mounted on said gimbal and spinning said flywheel;
   a lifting load pivoting clutch for making said gyro frame and said gimbal frame releasable; and
   a mechanism for canceling a reaction torque to be exerted on said rotational driving portion from said gimbal frame.

2. A lifting load attitude control system as set forth in claim 1, which further comprises:

   a resetting oblique rotation driving portion for obliquely rotating said gimbal upon returning said gimbal at initial position;
   a warm gear mechanism connected to said resetting oblique rotation driving portion;
   a resetting obliquely rotating clutch provided between said warm gear mechanism and said gimbal or said rotational driving portion and making them releasable; and
   control means for controlling rotation of said lifting load hanged on said lifting jig by controlling driving of said spinning driving portion, said rotational driving portion, and engagement and disengagement of said lifting load pivoting clutch and said resetting obliquely rotating clutch.

3. A lifting load attitude control system as set forth in claim 1 or 2, which further comprises a variable constant torque transmitting device provided between said gyro frame and said gimbal frame.

4. A method for controlling pivoting motion of a lifting load hanged by a lifting jig employing a lifting load attitude control system as set forth in claim 1, 2 or 3, comprising the steps of:

   placing said lifting load pivoting clutch in engaged condition, placing said resetting obliquely rotating clutch in disengaged condition and driving said spinning driving portion and said rotational driving portion during normal rotating operation; and
   placing said resetting obliquely rotating clutch in engaged condition, placing said lifting load pivoting clutch in disengaged condition and driving said resetting oblique rotation driving portion upon returning said gimbal to the initial position.

5. A lifting load attitude control system utilizing a gyro effect, comprising:

a lifting jig to be hanged in horizontal attitude for hanging a lifting load;
a gyro frame fixed to said lifting jig;
a gimbal frame rotatable about a rotating shaft perpendicular to a gimbal frame;
a gimbal rotatable about a rotation shaft extending perpendicular to a surface including said rotating shaft of said gimbal frame, with respect to said gimbal frame;
a flywheel capable of spinning about a spinning shaft perpendicular to a surface including said rotation shaft with respect to said gimbal;
a rotational driving portion mounted on said gimbal frame and driving said gimbal in forward and reverse direction;
a spinning driving portion mounted on said gimbal and spinning said flywheel;
a rotational position detecting sensor for detecting a rotational position of said gimbal;
said rotational driving portion controlling rotation of said gimbal from the rotational position toward initial position on the basis of the output if said rotational position detecting sensor; and
braking means for stopping said rotational driving portion when the rotational position of said gimbal substantially match with said initial position.

6. A method for controlling pivoting motion of a lifting load hanged on a lifting jig employing a lifting load attitude control system utilizing a gyro effect as defined in claim 5, comprising the steps of:

fixing said lifting jig or said lifting load on a stationary portion to make prohibiting them from rotation irrespective of forced rotation of said gimbal;
subsequently rotating said gimbal by said rotational driving portion for returning to said initial position.

7. A lifting load attitude control system utilizing a gyro effect, comprising:

a lifting jig handed in horizontal attitude for hanging a lifting load;
a gyro frame fixed to a lifting jig;
a gimbal frame rotatable about a rotation axis perpendicular to the gyro frame;
a gimbal rotatable about a rotation axis perpendicular to a surface including the rotation axis of said gimbal frame, relative to said gimbal frame;
a flywheel capable of spinning about a spinning shaft perpendicular to the surface including said rotation axis;
a rotational driving portion for rotating the gimbal mounted on said gimbal frame in the forward and reverse direction;
a spinning driving portion for spinning said flywheel mounted on said gimbal;
a rotational position detecting sensor for detecting a rotational position of said gimbal;
air ejecting means for generating a moment about a rotation shaft on said lifting jig for rotating the later from the rotational position of said gimbal to an initial position by reaction associating with air ejection on the basis of the output of said rotational position detecting sensor; and
braking means for stopping said rotational driving portion when the rotational position of said gimbal substantially match with said initial position.

FIG.1

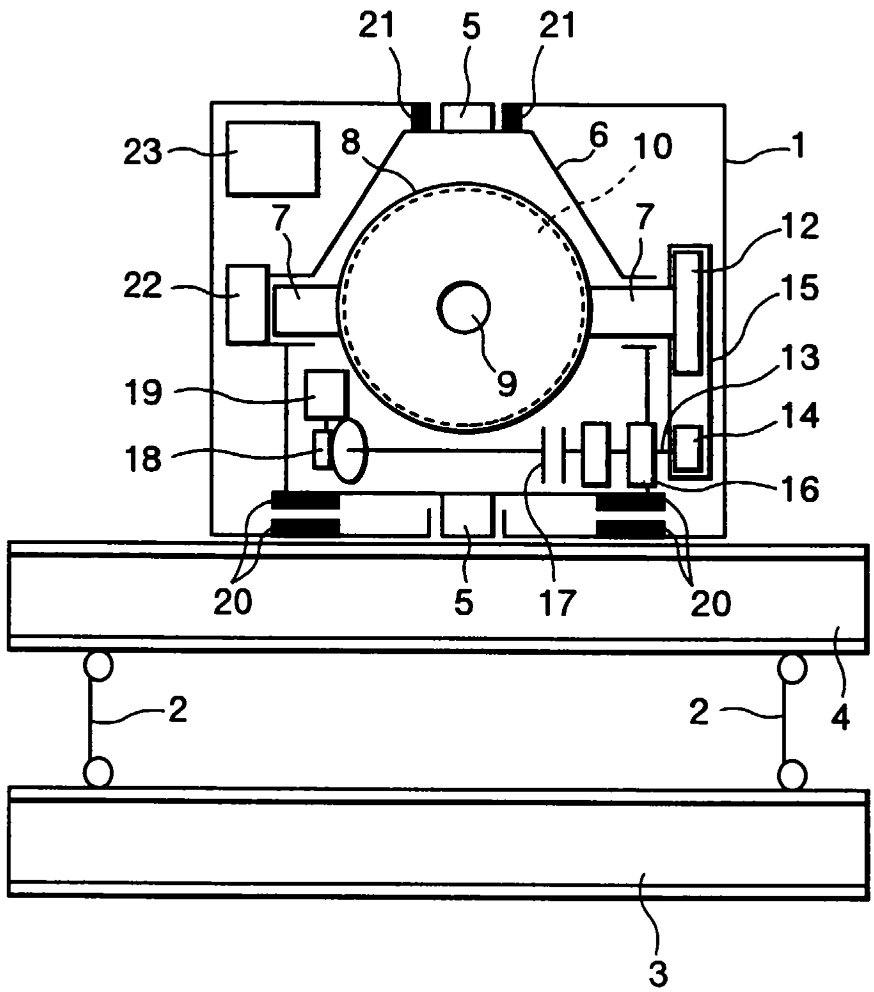
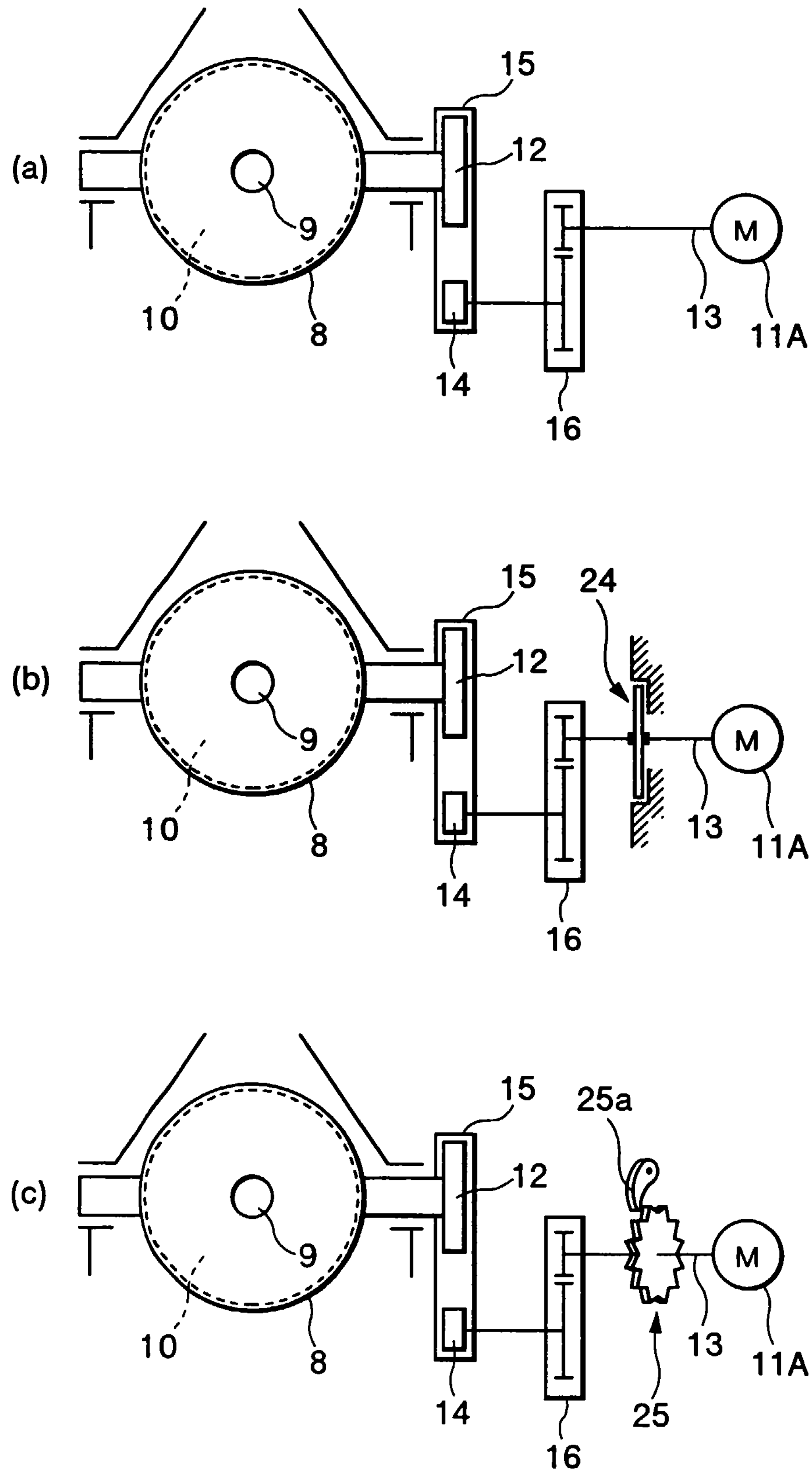


FIG.2


(a)
15
12
9
M
10
8
13
11A
14
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(b)
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24
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8
13
11A
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(c)
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25a
12
9
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8
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11A
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25
16

FIG.3

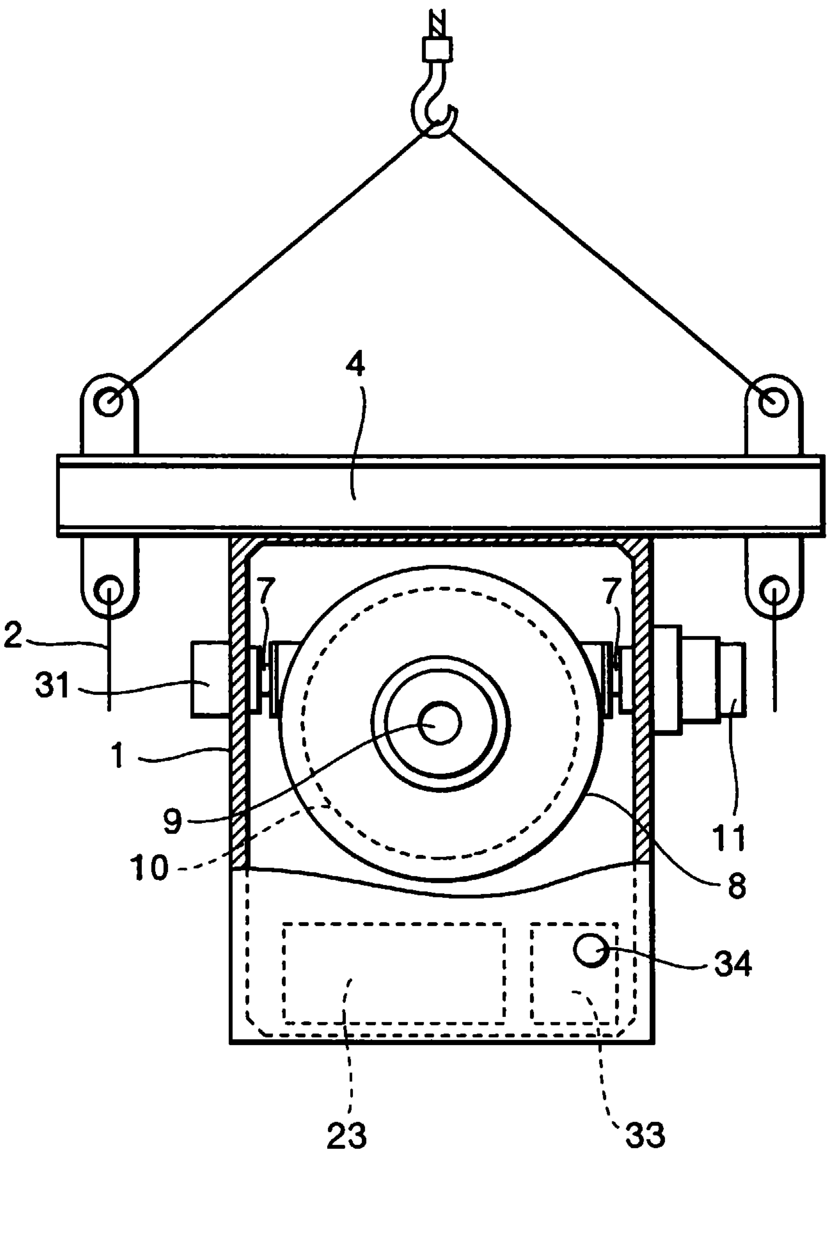


FIG.4

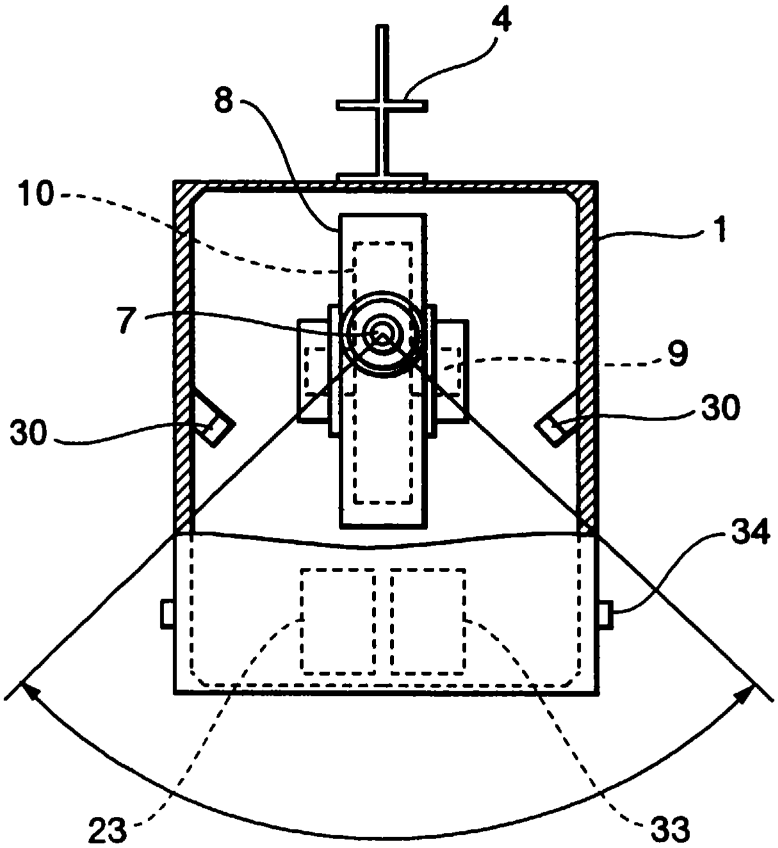


FIG.5

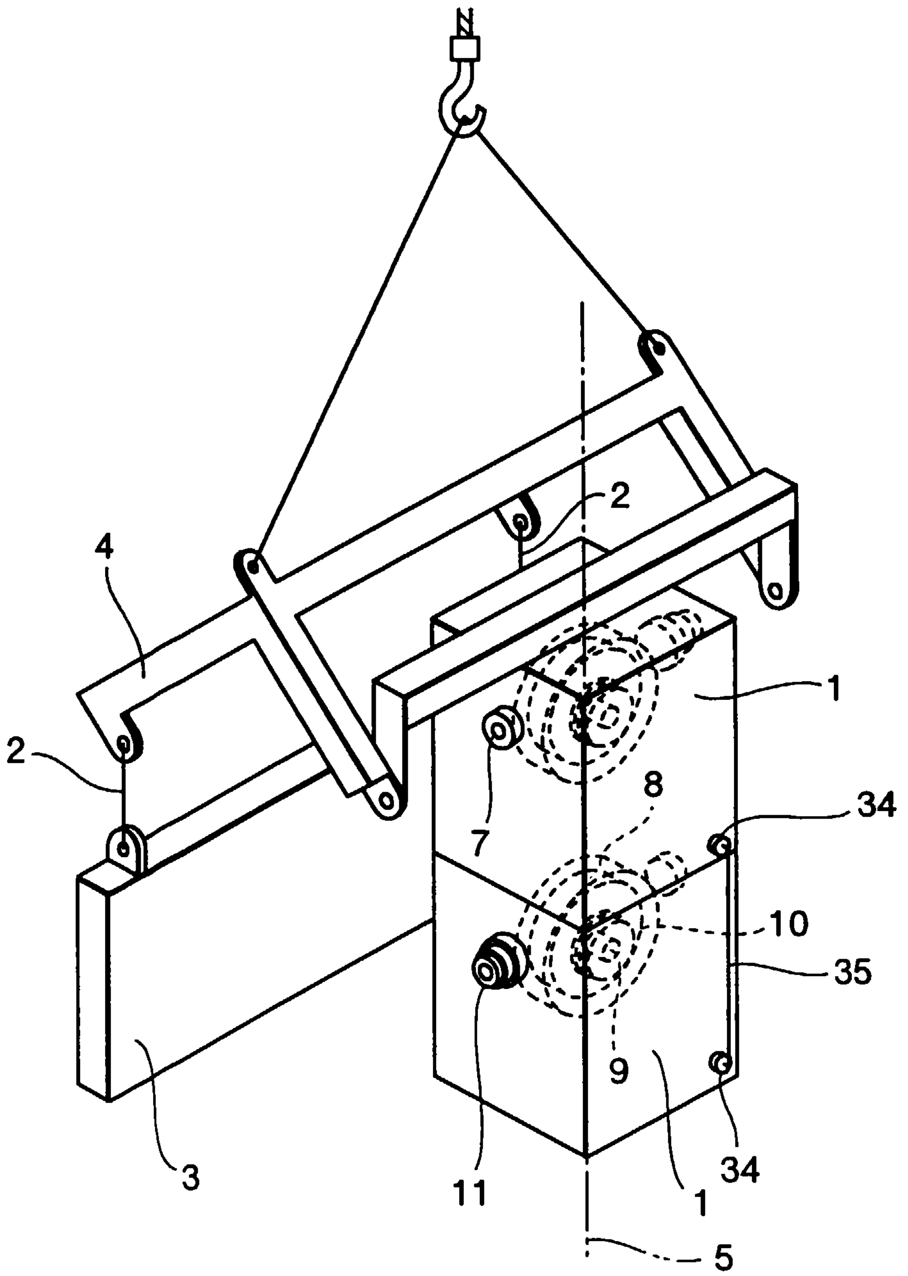
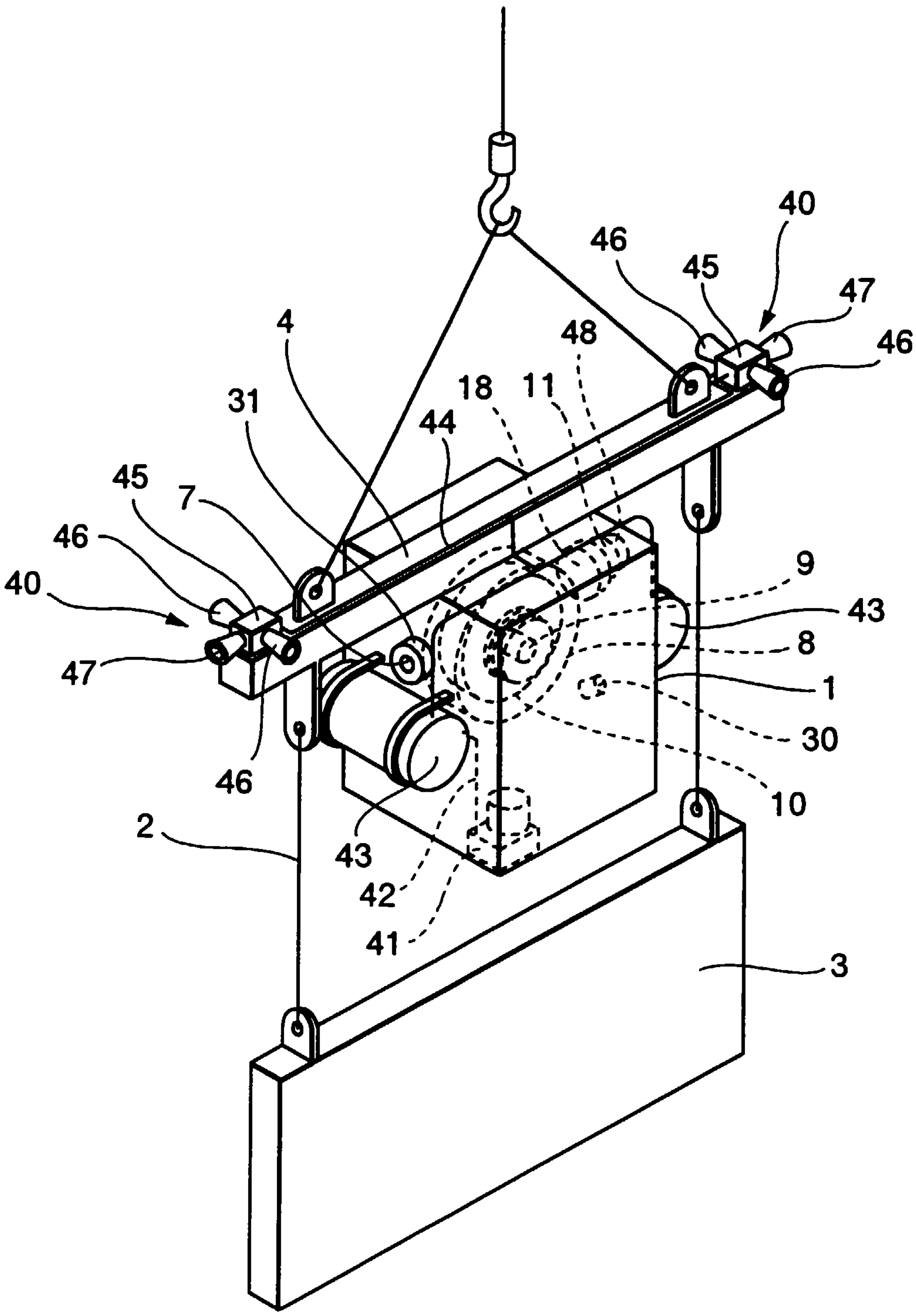


FIG.6



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EUROPEAN SEARCH REPORT

Application Number
EP 96 30 2779

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.6)
X A	DE-A-19 40 375 (SKAGIT CORP.) * the whole document * ---	1,4 2,5,7	B66C13/08
A	DE-A-20 35 367 (TAX) ---		
A	DE-A-20 09 847 (BLOHM & VOSS) ---		
A	DE-A-23 56 504 (KRUPP) -----		
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
			B66C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	9 October 1996	Van den Berghe, E

CATEGORY OF CITED DOCUMENTS

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