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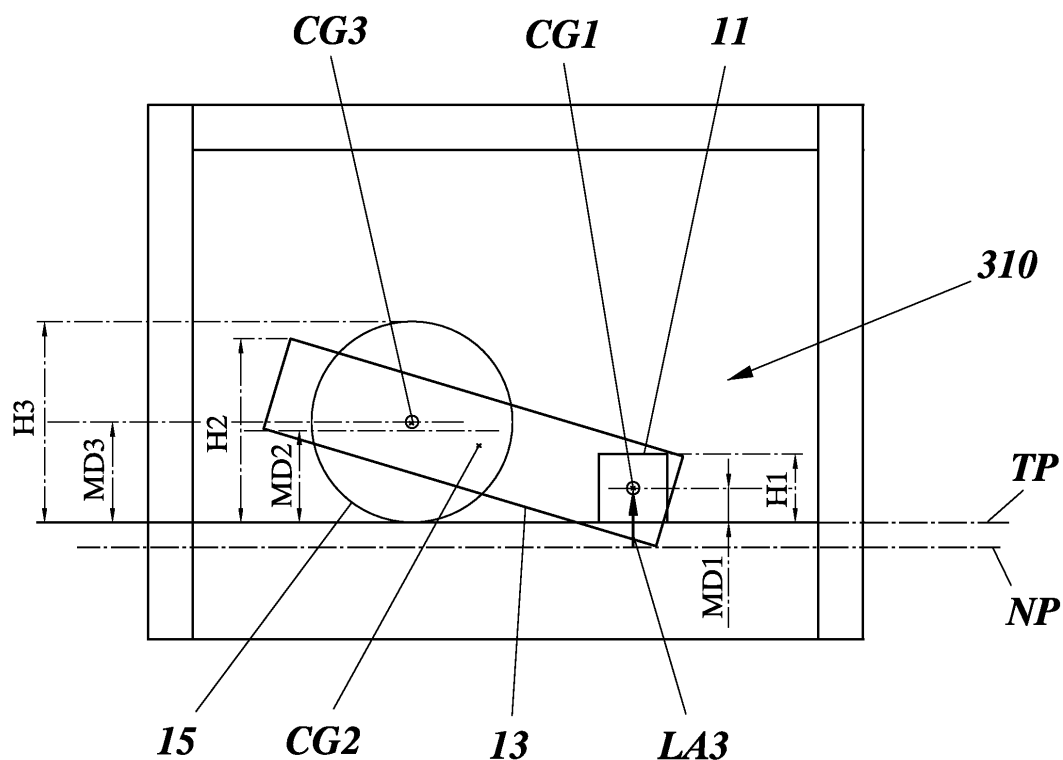
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(54) **Control system for hoisting device**

(57) For controlling relative movement between individual components (11, 13, 15) of a control system (310) for cargo hoisting devices comprising a trolley (2) adapted for movement along a crane girder (20) and having a structural part (4) supporting said control system, at least selected components (11, 13, 15) of the control system

(310) are positioned with their center of gravity (CG1, CG2 and CG3, respectively) lying at a maximum distance (MD1, MD2 and MD3, respectively,) from a top plane (TP) of the structural part that corresponds approximately to half the height (H1; H2; H3) of said component or components in a direction transversal to said top plane.

FIG. 6



Description

TECHNICAL FIELD

[0001] The present invention generally concerns hoisting devices that are used mainly for cargo handling and specifically relates to control systems for such hoisting devices.

BACKGROUND

[0002] Large cranes that are used for loading containers on and off cargo ships commonly have hoisting devices that include trolleys traveling on a track on a crane girder through a connection between the girder and usually a top frame of the trolley. The hoisting devices are equipped with control systems that are hosted on the trolley and that include for instance hoisting cables connected to cable drums that are in turn driven by motors - most commonly electrical motors - through a transmission, such as a gear box. During operation, the hoist-trolley system is suffering from vibrations. These vibrations are caused by either motor vibrations or sudden changes in the carried load, so called snag-loads. The effect of motor vibrations can usually be successfully minimized by separating the structural eigenfrequencies from the excitation frequencies of the motors.

[0003] The effect of ordinary snag-loads has been reduced by means of a presently commonly used snag-load protection system that may be hydraulic as well as mechanical. However, a severe snag-load, caused by a container getting stuck or hitting the ground, will still generate large transient loads that are transmitted to the trolley structure through the load carrying cables. A lower part of the trolley, hanging from the crane girder, is relatively weak and will start to vibrate. Such vibration of the lower part or bottom frame of the trolley generates relative movements between the components, such as the motors, gear box and cable drums, that are mounted on the frame. Relative movement between the gear box and the motors has generated a series of motor failures caused by contact between the rotor and the stator of an electrical DC motor, which is usually a consequence of failure of motor bearings.

SUMMARY

[0004] A general object of the present invention is to reduce the effect caused upon a hoisting control system by vibration induced into a hoisting device.

[0005] Another object of the invention is to provide an improved method of arranging components of a hoisting control system to eliminate or at least minimize inter-component movement thereof that is caused by vibrations induced into the trolley structure.

[0006] Yet another object of the invention is to provide an improved hoisting trolley that is provided with such an arrangement of the control system components thereon.

[0007] These and other objects are met by the invention as defined by the accompanying patent claims.

[0008] The invention generally relates to hoisting devices of the kind that are intended for use on a cargo handling crane and that comprise a hoisting control system accommodated or hosted on a trolley traveling on a crane girder. Briefly, the present invention is based on the idea of minimizing the detrimental effects of load related vibration upon components of the control system by at least significantly reducing the distance between the centre of gravity of at least selected control system components and a control system carrying structural part of the trolley.

[0009] In one aspect of the invention the favourable effects thereof are achieved by supporting the selected components of the control system approximately directly on a top plane of the structural part of the trolley.

[0010] In another aspect of the invention said favourable effects are achieved by arranging said selected components integrated with the structural part of the trolley and with their centre of gravity lying approximately in the neutral plane of said structural part.

[0011] Preferred developments of the basic inventive idea as well as embodiments thereof are specified in the dependent subclaims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] The invention, together with further objects and advantages thereof, will be best understood by reference to the following description taken together with the accompanying drawings, in which:

Fig. 1A is a schematical side view of a prior art hoisting trolley with control system;

Fig. 1B is a schematical top view of the prior art hoisting trolley of Fig. 1A;

Fig. 2A is a schematical illustration, in a side view like the one in Fig. 1A, of an exemplary hoisting trolley having a control system that is arranged in accordance with a first embodiment of the invention;

Fig. 2B is a schematical side view of the first embodiment of the invention, as seen in a direction transversal to that of Fig. 2A;

Fig. 3A is a schematical illustration, in a side view like the one in Fig. 1A, of an exemplary hoisting trolley with a control system in accordance with a second embodiment of the invention;

Fig. 3B is a schematical side view of the second embodiment of the invention, as seen in a direction transversal to that of Fig. 3A;

- Fig. 4A is a schematical illustration, in a side view like the one in Fig. 1A, of an exemplary hoisting trolley with a control system in accordance with a third embodiment of the invention;
- Fig. 4B is a schematical side view of the third embodiment of the invention, as seen in a direction transversal to that of Fig. 4A;
- Fig. 5A is a schematical illustration, in a side view like the one in Fig. 1A, of an exemplary hoisting trolley with a control system in accordance with a forth embodiment of the invention;
- Fig. 5B is a schematical side view of the forth embodiment of the invention, as seen in a direction transversal to that of Fig. 5A; and
- Fig. 6 is a schematical illustration of a principal definition of one aspect of the invention.

DETAILED DESCRIPTION

[0013] Figs. 1A-B very schematically illustrate a typical prior art hoisting device 1 comprising a trolley 2 and a hoisting control system 10 accommodated on the trolley 2. Such hoisting devices 1 are commonly used on cranes for handling cargo, such as containers. The trolley 2 has an upper frame 3 supporting a number of wheels 21. The wheels are adapted to roll on a track 22 that is attached to an upper face of a crane girder 20 and that allow the trolley to travel along the crane girder for the transfer of cargo suspended therefrom. The hoisting control system 10 comprises components such as cable drums 15 to which hoisting cables (not shown) are connected, a transmission 13, commonly a gear box, and motors 11 for operating the cable drums 15 through the transmission 13. The components of the control system 10 are supported on a lower frame 4 of the trolley 2 through drum stands 16, a transmission seat 14 and motor seats 12, respectively. The drums 15 have a considerable diameter and they are positioned above and clear from the bottom frame 4. This means that the respective drum axles 15A and gear box as well as motor shafts 13A and 11A, respectively, will be disposed in a common plane AP that is located well above the bottom frame 4.

[0014] The described design will cause the centre of gravity CG1, CG2 and CG3, respectively, of the respective components 11, 13, 15 to be located well above the bottom frame 4. Accordingly, a long lever arm LA is created for the mass of each component 11, 13, 15 of the control system 10, which will be unfavorable with regard to the transfer of load related vibration thereto. Due to this long lever arm LA extending from a neutral plane NP of the bottom frame 4, vibration of the bottom frame 4 will be amplified and will generate large relative movements between control system components 11, 13, 15. In Figs. 1A-B this is exemplified by the multiple dashed

outlines of the motors and the transmission. Of particular interest is the movement in the direction radial to the motor axles, especially for the typical cases where the cable drum drive motors are DC-motors having a minimal gap between rotor and stator. Relative movement between the gear box and the motors in this direction may and has generated a series of motor failures, usually caused by failure of motor bearings leading to contact between the rotor and the stator. Thus, it is important to reduce the amplitude of this relative motion.

[0015] One general prior art solution to such problems related to relative movement between components has been to strengthen the support structures of the control system components, as is generally indicated at 12A for one of the motor seats 12 in Fig. 1A. As was indicated in the introduction, specific solutions to these problems have in the prior art focused either on minimizing the effect of motor vibrations by separating the structural eigenfrequencies from the excitation frequencies of the motors or on reducing the effects of sudden changes in the carried load, so called snag-loads, by means of snag-load protection systems. However, as was mentioned initially, severe snag-loads will generate large transient loads that are transmitted to the trolley structure through the load carrying cables. With the bottom frame of the trolley being relatively weak, it will start to vibrate. Therefore, in such cases, the prior art solutions are insufficient in reducing the relative motion between the components and thereby the risk of motor failure.

[0016] The invention will now be explained with reference to exemplifying embodiments thereof, which are illustrated in the accompanying drawing figures 2A-B, 3A-B, 4A-B and 5A-B, respectively. Said exemplifying embodiments of the invention all relate to an application of the basic inventive principles to a partially and very schematically outlined hoisting trolley 2 of the general kind that is well known within the art of cargo handling and that was illustrated in Figs. 1A-B. It shall be emphasized, though that the illustrations are for the purpose of describing preferred embodiments of the invention and are not intended to limit the invention to the use thereof on or for any specific trolley design.

[0017] A first exemplifying embodiment of the invention will now be described with reference to Figs. 2A-B, wherein a hoisting control system 110 is supported by a structural part 4, such as the described bottom frame, of a trolley 2 like the one in Figs. 1A-B. The control system 110 is represented by the same schematically illustrated components as in Figs. 1A-B, namely cable drums 15, transmission or gear box 13 and cable drum drive motors 11. At this stage it shall be emphasized that in practical applications the control system may also comprise additional components as well as differently configured components having corresponding functions.

[0018] In the embodiment of Figs. 2A-B all of the illustrated components 11, 13, 15 of the control system 110 are to some extent integrated with the structural part 4 in the sense that they or major parts thereof are received

within the structural part 4. In the normal case, the components 11, 13, 15 are not integrated in the part 4 in the sense of being in themselves structural parts thereof. Instead the components are preferably supported by the part 4 through appropriate means, such as vibration absorbing bearings that are not specifically illustrated in the drawings. Such vibration absorbing bearings may be of any appropriate kind known to persons skilled within this field and are exemplified very schematically in Figs. 5A-B illustrating a forth embodiment of the invention.

[0019] In this first embodiment all of the mentioned components, namely the cable drum drive motors 11, the transmission 13 and the cable drums 15 are integrated with the structural part 4, with the motor shafts 11A, the transmission output shaft 13A as well as the cable drum axles 15A being located in a common axial plane AP. Specifically, the components 11, 13, 15 are positioned with their center of gravity CG1, CG2 and CG3, respectively, lying in or at least approximately in the neutral plane NP of the trolley 2 structural part 4 that may be defined as a plane where compression and tension forces are zero when the structural part 4 is subjected to pure bending and that does here coincide with the plane AP being an axial plane of the motors 11. This movement of the centre of gravity CG1, CG2 and CG3, respectively, of the components 11, 13, 15 down to the neutral plane NP will practically bring the lever arm of the mass of each component down to zero, to thereby significantly reduce or almost eliminate relative motion of the components caused by vibration induced into the structural part 4.

[0020] For simplicity, the centre of gravity CG1, CG2 and CG3, respectively, of all components 11, 13, 15 have been illustrated here as lying exactly in the same plane, namely in the axial plane AP coinciding with the neutral plane NP, although this may normally not be the case in practical applications. However, such variations will not affect the favourable results obtained with the invention to any greater extent. As a general rule, especially where DC-motors are concerned, it is vital that radial relative movement between the motors and the transmission are reduced. Therefore, the base of the invention will normally be the positioning of the motors, as will be clear from embodiments described further below.

[0021] In Figs. 3A-B is illustrated an alternative, second embodiment of the invention, wherein only selected components of the control system 210, namely the motors 11, are arranged with their centre of gravity CG1 lying approximately in the neutral plane NP. Preferably, and especially in the case where electrical DC motors 11 are used as cable drum drive motors, said motors are always included in the selected components, as in the illustrated embodiment. The cable drum motors 11 are lowered so that their centre of gravity CG1 is positioned approximately in the neutral plane NP of the trolley 2 structural part 4. Thus, the motors 11 are integrated with the structural part 4, whereas the cable drums 15 are supported on a top plane TP of the structural part 4. The transmission 13 is rotated to enable the connection to

the drums 15 as well as to the motors 11, leaving the transmission 13 in a tilted position with regard to the axial plane AP of the motors 11, with only one end thereof being partly integrated with the structural part 4. In this embodiment, with the motors 11 brought down to the neutral plane NP, the lever arm of their mass will once again be reduced practically to zero. The lever arm of the mass of the other components 13, 15 will not be zero but will be much shorter than by the prior art arrangement exemplified in Fig. 1A, thereby once more significantly reducing or almost eliminating relative motion of the most essential components being the motors and the transmission.

[0022] A further modification of the invention is illustrated as a third embodiment in Figs. 4A-B. Here, selected components, namely the motors 11 and the drums 15, are supported on a top plane TP of the structural part 4, likewise preferably through vibration absorbing bearings. Since the diameter of the cable drums 15 is considerably larger than that of the drive motors 11, the transmission 13 is again rotated to enable the connection to the drums 15 as well as to the motors 11, leaving the transmission 13 in a slightly less tilted position than in the second embodiment. The motors 11 are in this case brought down approximately to the top plane TP of the structural part so that the lever arm LA3 of their mass will be essentially shortened compared to the prior art, as will the lever arm of the mass of the other components 13, 15. Again, relative motion between the vital components of the control system 310 is significantly reduced.

[0023] In the forth embodiment of the invention that is illustrated in Figs. 5A-B the components 11, 13, 15 of the control system 410 are, like in the first embodiment of Figs. 2A-B, positioned with the motor shafts 11A, the transmission output shaft 13A as well as the cable drum axles 15A located in a common axial plane AP. This means that the transmission 13 will not be tilted. However, in this forth embodiment only the cable drums 15 are partly integrated in the structural part 4, whereas the transmission 13 and the motors 11 are supported approximately directly on the top plane TP of the structural part 4. In this case, vibration absorbing bearings 18 for supporting the motors 11 are illustrated as being positioned on the top plane TP instead of being integrated in the structural part 4. This will indeed increase the lever arm LA4 slightly but it will still be considerably shorter than by the prior art arrangements. It shall be obvious though, that in a variation of this forth embodiment the motors 11 may be supported directly on the top plane TP, with the bearings integrated in the structural part 4, meaning that the transmission 13 may likewise be lowered accordingly, partly integrating it with the structural part.

[0024] Principally, summarizing the above described embodiments of the invention, the objects thereof are achieved by positioning selected vital components of the control system with their center of gravity lying approximately in the neutral plane of the structural part of the

trolley, such as in the first and second embodiments, or at a specified maximum distance above a top supporting plane of said structural part of the trolley, said distance being significantly reduced when compared to prior art systems. With reference additionally to Fig. 6, said maximum distance will be specified for all embodiments with the aid of the control system 310 of the third embodiment that was illustrated in Figs. 4A-B. The maximum distance of the centre of gravity CG1, CG2 and CG3, respectively, of the selected component or components above the top plane TP of the structural part 4 of the trolley may be determined as a distance MD1, MD2 and MD3, respectively, that corresponds approximately to half the overall height H1, H2 and H3, respectively, of said component or components above the structural part in a direction transversal to said top plane TP. For electrical DC motors said height is equal to what is generally referred to as the axial height of the motors.

[0025] The importance of the favourable effects achieved by means of the described invention is accentuated by the ever stronger requirements within the cranes business to increase the overall productivity. An offer that provides a cost effective productivity increase has a strong competitive advantage. The proposed solution provides the advantage of significantly reducing the relative displacement between the components, thereby increases the expected life time of the components and reduces the risk for unplanned stops due to fault cases during normal operation, thereby increasing the system availability. As indicated above, in a further development of the inventive idea, the components may in theory also be integrated in the structural part in the sense of being in themselves structural parts thereof. However, presently such configurations have in practice been disregarded as a result of the higher costs that would be involved for the design and manufacture of motors and other components having the required strength for such configurations. Such a further development of the proposed solution would otherwise provide higher stiffness for a given trolley mass, which would in turn mean that the trolley mass can be reduced. Thereby the power needed to operate the trolley can be reduced or alternatively the lifting capacity can be increased. A stiffer trolley also enables the choice of low inertia motors, which increases the efficiency of the system. Therefore the principles of the invention may be utilized in different ways depending on which properties that give the largest economical advantage i.e. weight reduction, stiffness increase, relative displacement decrease etc. It is presently believed that the trend within the cranes business is towards higher lifting speeds and higher lift masses. This implies that the stresses/strains in the structures will increase and furthermore the trend in motor development is towards higher power density this gives that the importance of proper dynamic behavior of the structures can be expected to increase.

[0026] In alternative, but not specifically illustrated embodiments of the invention variations of the different il-

lustrated parts of the control system may be employed without departing from the scope of the invention. Although the invention has been described and illustrated with specific reference to an application thereof to the type of hoisting trolley that has been schematically illustrated and described herein and that is primarily intended for use by a container crane, the invention is in no way restricted to such applications. The basic principles of the invention may therefore be applied to other types of cargo handling crane trolleys. Likewise, the invention is not to be restricted to the use of any specific type or design of the cable drum drive motors or the transmission.

[0027] The invention has been described in connection with what is presently considered the most practical and preferred embodiments, but it is to be understood that the invention is not limited to the disclosed embodiments. The invention is therefore intended to cover various modifications and equivalent arrangements included within the spirit and scope of the appended claims.

Claims

1. A method of controlling relative movement between individual components, including cable drum drive motors (11), transmission (13) and cable drums (15), of control systems (10; 110; 210; 310; 410) for cargo hoisting devices (1) comprising a trolley (2) adapted for movement along a crane girder (20) and having a structural part (4) for supporting said control system, **characterized by** positioning at least selected components (11, 13, 15) of the control system (110; 210; 310; 410) with their center of gravity (CG1, CG2 and CG3, respectively) lying at a maximum distance (MD1, MD2 and MD3, respectively,) from a top plane (TP) of the structural part that corresponds approximately to half the height (H1; H2; H3) of said component or components in a direction transversal to said top plane.
2. A method according to claim 1, **characterized by** supporting selected components (11, 13, 15) of the control system (210; 310; 410) approximately directly on the top plane (TP) of the structural part (4) of the trolley (2).
3. A method according to claim 1, **characterized by** integrating selected components (11, 13, 15) of the control system (110; 210) in the structural part (4) of the trolley (2), with their center of gravity (CG1, CG2 and CG3, respectively) lying approximately in a neutral plane (NP) of said structural part (4).
4. A method according to any of claims 1-3, **characterized by** including the cable drum drive motors (11) in the selected components (11, 13, 15).
5. A method according to any of claims 1, 2 or 4, **char-**

acterized by:

- supporting the cable drum drive motors (11) of the control system (310; 410) on the structural part (4) of the trolley (2), positioned with their center of gravity (CG1) lying at approximately their axial height (H1) above the top plane (TP) of the structural part; 5
 - rotating the transmission (13) to enable connection thereof to the motors that are supported on the structural part; thereby 10
 - providing the transmission in a tilted position relative to a motor axial plane (AP).
6. A method according to any of claims 1, 3 or 4, **characterized by:** 15
- integrating the cable drum drive motors (11) of the control system (210) with the structural part (4) of the trolley (2), positioned with their center of gravity (CG1) lying approximately in the neutral plane (NP) of the structural part; 20
 - rotating the transmission (13) to enable connection thereof to the motors that are integrated in the structural trolley part; thereby 25
 - providing the transmission in a tilted position relative to a motor axial plane (AP).
7. A method according to any of claims 1, 2 or 4, **characterized by** supporting all of the selected control system (410) components (11, 13, 15), including drive motors (11), transmission (13) and cable drums (15) on the top plane (TP) of the structural part (4) of the trolley (2), each positioned with their center of gravity (CG1, CG2 and CG3, respectively) lying approximately in an axial plane (AP) of the motors. 30
8. A method according to any of claims 1, 3 or 4, **characterized by** integrating all selected control system (110) components (11, 13, 15), including drive motors (11), transmission (13) and cable drums (15), with the structural part (4), each positioned with their center of gravity (CG1, CG2 and CG3, respectively) lying approximately in a neutral plane (NP) of the structural part. 40
9. A trolley (2) for cargo hoisting devices (1), said trolley accommodating components of a hoisting device control system (10; 110; 210; 310; 410), including cable drum drive motors (11), a transmission (13) and cable drums (15), and having means (21) for traveling along a crane girder (20) and a structural part (4) for supporting said control system, **characterized in that** at least selected components (11, 13, 15) of the control system (110; 210; 310; 410) are supported with their center of gravity (CG1, CG2 and CG3, respectively) lying at a maximum distance (MD1, MD2 and MD3, respectively,) from a top plane (TP) of the structural part that corresponds approximately to half the height (H1; H2; H3) of said component or components in a direction transversal to said top plane. 45
10. A trolley (2) according to claim 9, **characterized in that** selected components (11, 13, 15) of the control system (210; 310; 410) are supported approximately directly on the top plane (TP) of the structural part (4) of the trolley (2). 50
11. A trolley (2) according to claim 9, **characterized in that** selected components (11, 13, 15) of the control system (110; 210) are integrated in the structural part (4) of the trolley (2), with their center of gravity (CG1, CG2 and CG3, respectively) lying approximately in a neutral plane (NP) of said structural part (4). 55
12. A trolley (2) according to any of claims 9-11, **characterized in that** the cable drum drive motors (11) are included in the selected components (11, 13, 15).
13. A trolley (2) according to any of claims 9, 10 or 12, **characterized in that:**
- The cable drum drive motors (11) of the control system (310; 410) are supported on the structural part (4) of the trolley (2), positioned with their center of gravity (CG1) lying at approximately their axial height (H1) above the top plane (TP) of the structural part; and
 - The transmission (13) is provided in a tilted position relative to a motor axial plane (AP).
14. A trolley (2) according to any of claims 9, 11 or 12, **characterized in that:**
- the cable drum drive motors (11) of the control system (210) are integrated with the structural part (4) of the trolley (2) and are positioned with their center of gravity (CG1) lying in the neutral plane (NP) of the structural part; and
 - The transmission (13) is provided in a tilted position relative to a motor axial plane (AP).
15. A trolley (2) according to any of claims 9, 10, or 12, **characterized in that** all of the selected control system (410) components (11, 13, 15), including motors (11), transmission (13) and cable drums (15), are supported on the top plane (TP) of the structural part (4) of the trolley (2) and are each positioned with their center of gravity (CG1, CG2 and CG3, respectively) lying approximately in an axial plane (AP) of the motors.
16. A trolley (2) according to any of claims 9, 11, or 12, **characterized in that** all of the selected control system (110) components (11, 13, 15), including motors

(11), transmission (13) and cable drums (15), are integrated with the structural part (4) and are each positioned with their center of gravity (CG1, CG2 and CG3, respectively) lying approximately in a neutral plane (NP) of the structural part.

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17. A trolley (2) according to any of claims 9-16, **characterized in that** the cable drum drive motors (11) are electrical DC motors and **in that** the transmission (13) is a gear box.

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18. A trolley (2) according to any of claims 9-17 having a top frame (3) carrying the means (21) for traveling along a crane girder (20), **characterized by** a bottom frame (4) being connected to the top frame and serving as the trolley structural part supporting said control system (110; 210; 310; 410).

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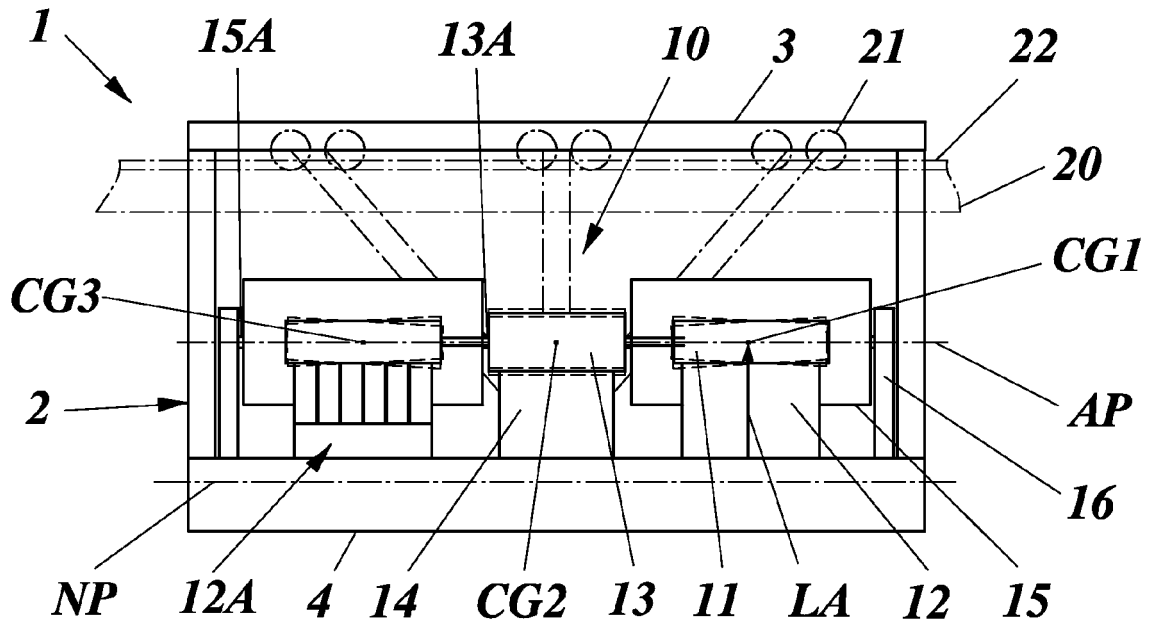


FIG. 1A (PRIOR ART)

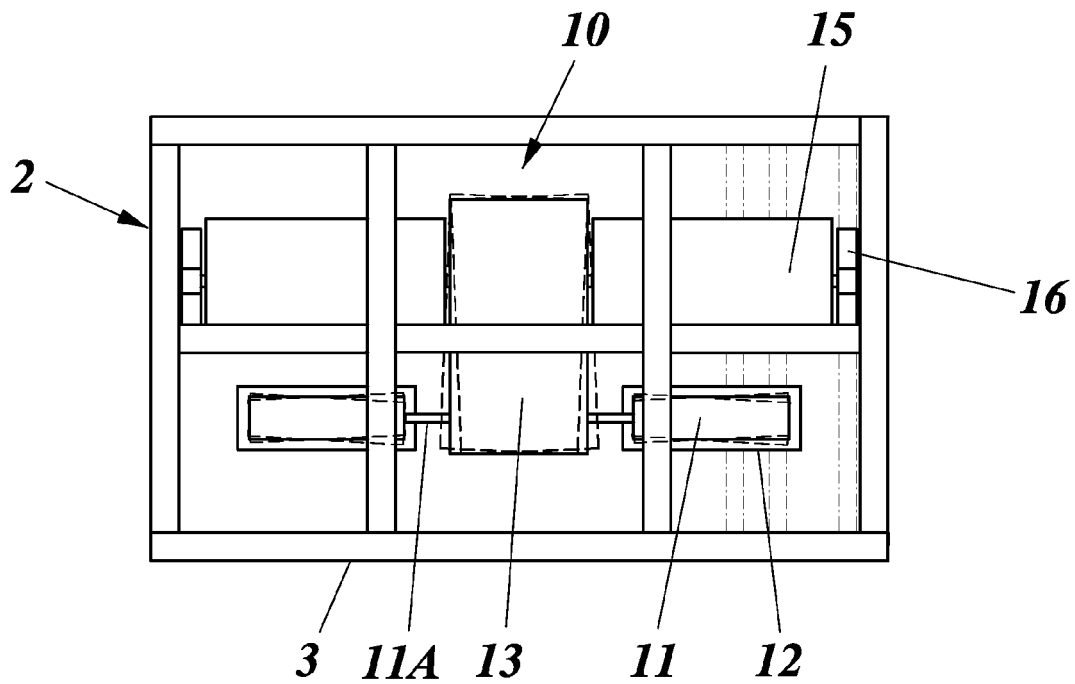


FIG. 1B (PRIOR ART)

FIG. 2A

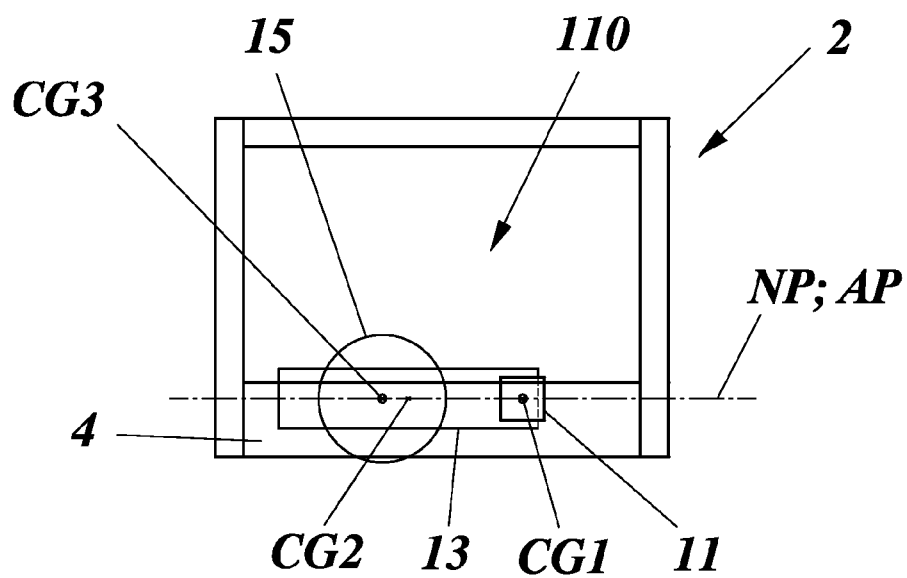
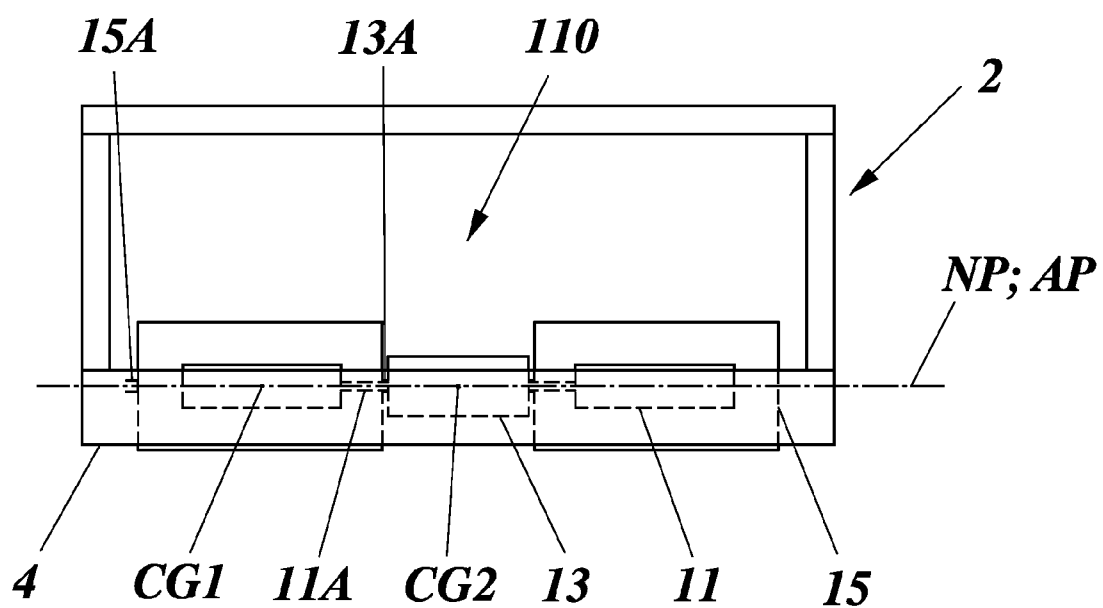


FIG. 2B

FIG. 3A

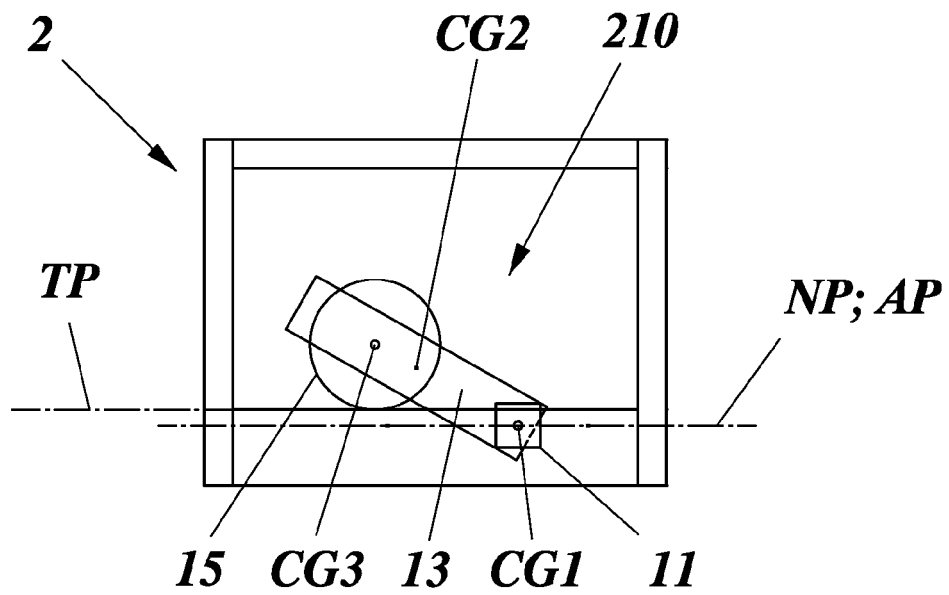
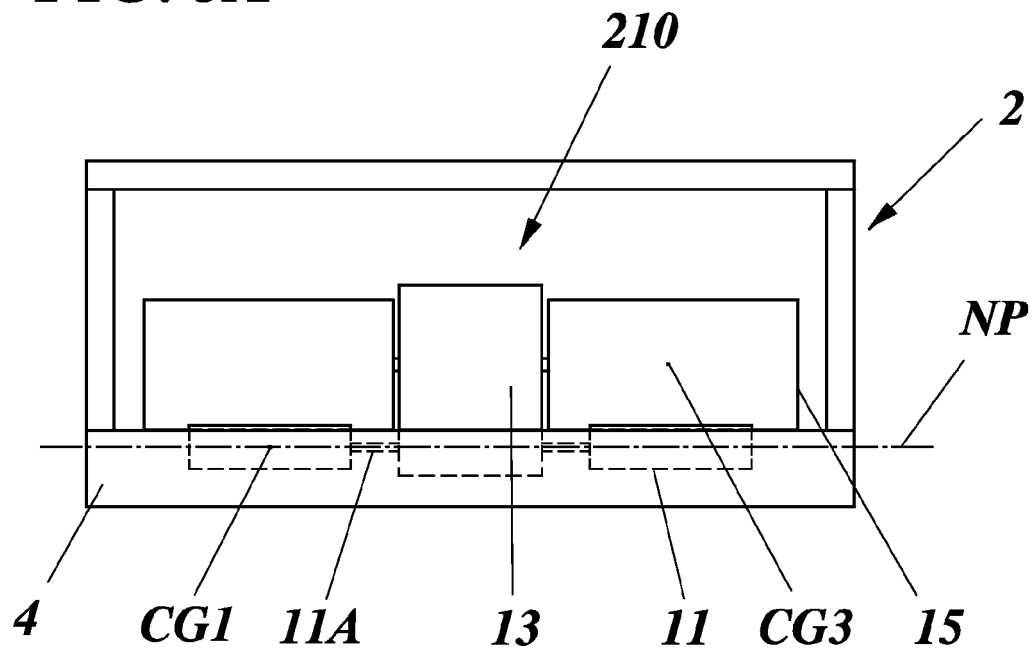


FIG. 3B

FIG. 4A

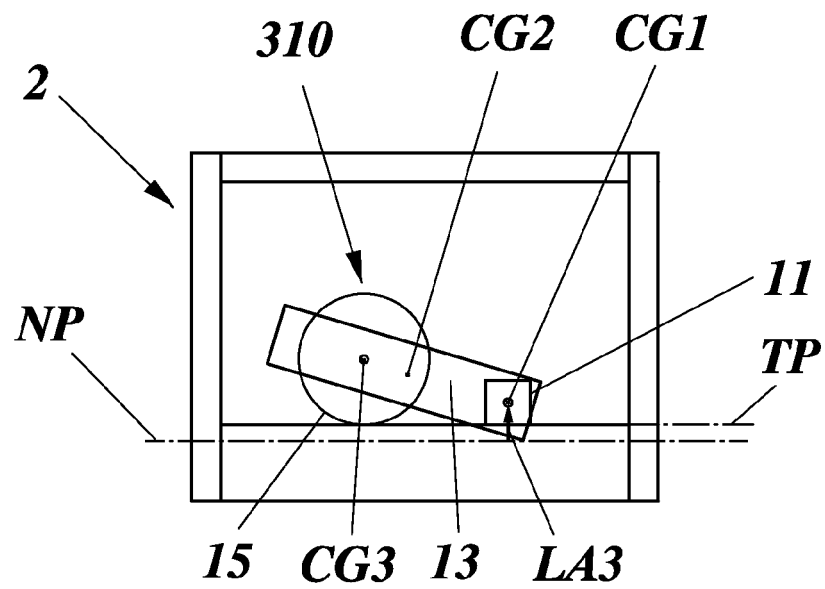
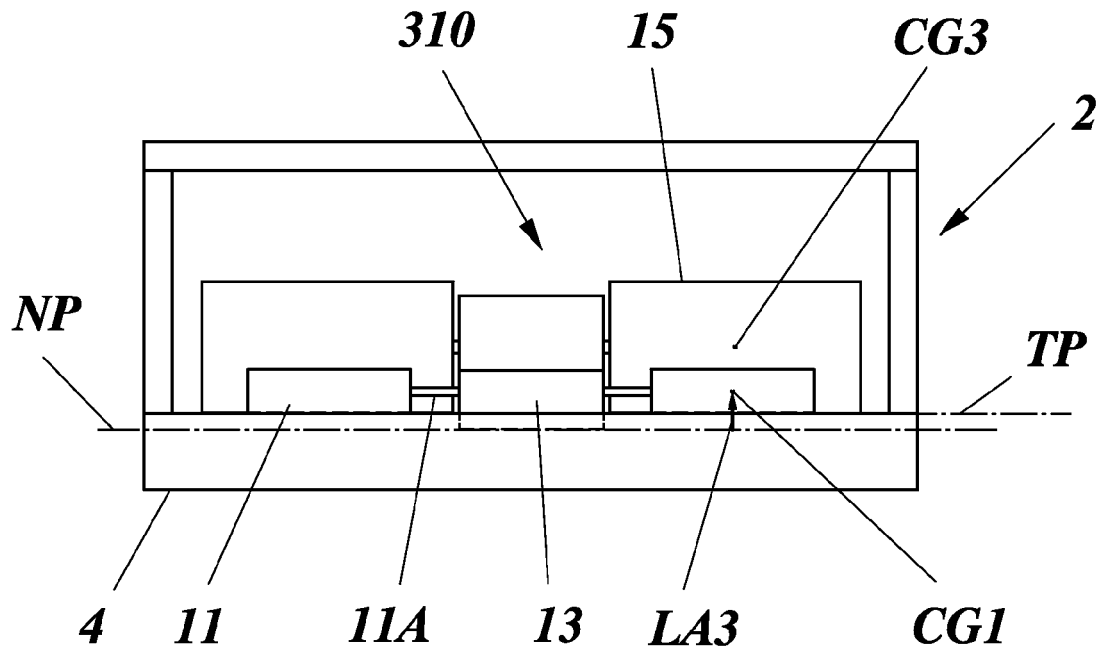
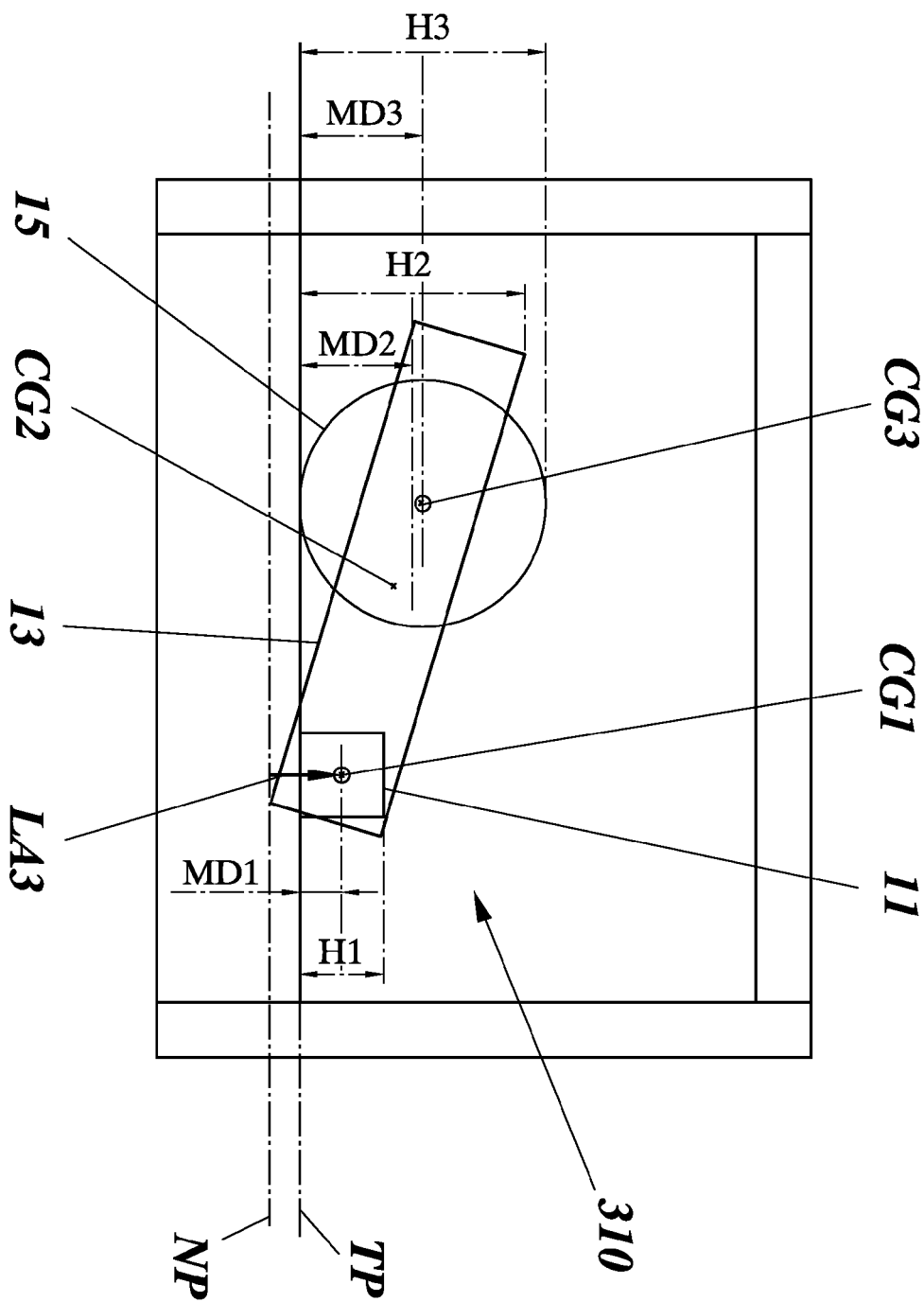


FIG. 4B

FIG. 6





European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 06 12 0723

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	GB 1 158 109 A (MATTERSON LTD) 16 July 1969 (1969-07-16) * the whole document * -----	1,3,4,6, 8,9,11, 12,14, 16-18	INV. B66C11/04 B66C13/06 ADD. B66C19/00
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X	FR 2 839 302 A1 (NFM TECH [FR]) 7 November 2003 (2003-11-07) * abstract * * page 2 - page 6 * * figure 2 * -----	1,5,9, 13,18	
			TECHNICAL FIELDS SEARCHED (IPC) B66C
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 20 February 2007	Examiner Sheppard, Bruce
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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EPO FORM 1503 03/82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 06 12 0723

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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