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(54) METHOD AND ARRANGEMENT FOR CONTROLLING A CRANE

(57) The present invention relates to a method and arrangement for controlling a crane (1). A crane of this type comprises, among other things, a main boom (2) with a possible drive member (9), a trolley (4) having a drive motor (5) to drive the trolley along the main boom and a hoist block (6) for manoeuvring a hoist rope (7) and a hoist hook (8) arranged thereto. The speed of the hoist block in relation to its environment is regulated by at least one speed meter that measures the speed of the hoist block, and an angle gauge (10) that determines the position of the hoist rope in relation to its vertical rest position. By determining the angle (α) of the hoist rope in relation to its vertical rest position (11), the drive motor or drive members can be manoeuvred so as to perform with the smallest possible swing the transport command (15) given by a user (16) to the crane.

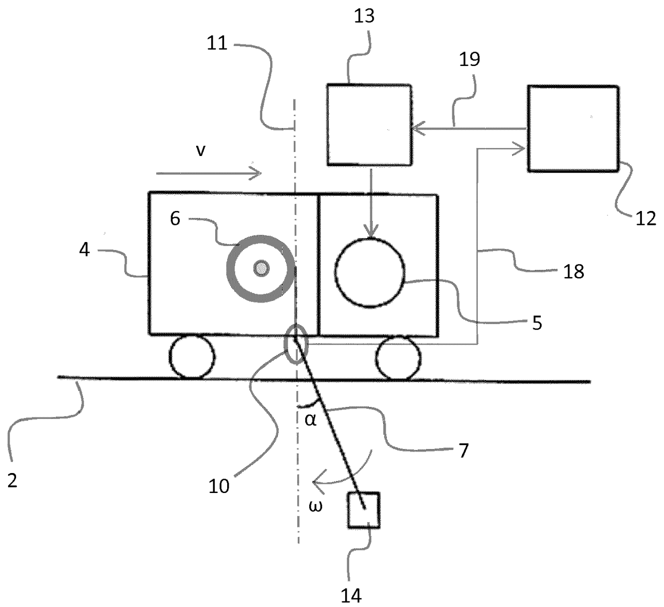

FIG. 4

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Description

Technical field

[0001] The present invention relates to a method according to the preamble of claim 1. The aim of the method is to minimize the swinging of a load transported by a crane.

[0002] The invention also relates to an arrangement according to the preamble of claim 7, with which this minimization of the load's swinging can be achieved.

[0003] It is known to use cranes of different sizes and power in industrial and workshop facilities to move particularly heavy objects between production or work locations. A bridge crane is a type of crane with a load-bearing structure comprising a main boom that preferably rests on fixed parallel support beams, along which the main boom can be moved. These beams are usually positioned at each end of the main boom, but there are bridge cranes with beams positioned on top of each other, in which case the main boom extends between the beams. A crane has a trolley that can be moved along its main boom. An example of such a trolley is a telpher that can be moved on rails or directly on bottom flanges of a bridge crane's main boom. The trolley comprises, among other things, a drive motor to drive it along the main boom, and a power-driven hoist block equipped with ropes, wires or chains.

[0004] Often the effectivity of work is determined on how quickly a load can be moved with a crane. Owing to the inertia of the object being moved with the crane, the load will generally swing in a greater or less degree. If the load is not too heavy, the swinging can be reduced by hand, but often it is necessary to manage the movements of the trolley and main boom to maintain a safe and stable transport of the load. This management requires great skill and experience of the crane operator, characteristics that are not always available in a stressful work situation.

[0005] So as to facilitate the use of cranes, various more or less automatic control systems have been developed during the years for the purpose of diminishing the swinging that occurs in objects or loads, when they are transported parallel to the ground in industrial or workshop facilities. However, many of these solutions have proven to be ineffective as well as costly to use and maintain. Very few of these known solutions can be utilised to upgrade older cranes by simple and quick means.

[0006] Examples of such control systems can be found in patent publication GB 1 183 126, for example. It states that swinging can be reduced by altering the movement rate of the load by two equally long and symmetrical acceleration periods that are separated by a phase displacement of half a swinging period from each other. This way, a transport movement is achieved, when the load of the crane does not swing before a new speed setting is given. The described solution relates to an electromechanical arrangement that is based on using several measurements to determine the transport times of the load and its movement in relation to the crane, for instance. The measurements are difficult to make sufficiently quickly and reliably to be able to regulate the swinging of the load even during short transport intervals.

[0007] A solution according to publication US 5 219 420 endeavours to regulate the swinging of the load at any random time instant during the transport of the load. This solution, too, describes an arrangement that is based on using several measurements to determine continuously the transport times of the load and its movement in relation to the crane, for instance. Like in the earlier solution, the measurements are difficult to make sufficiently quickly and reliably to be able to regulate the swinging of the load even during short transport intervals.

[0008] Finally, we refer to a solution according to WO 103/041770, which also teaches that in addition to the several measurements for the purpose of continuously determining the transport times of the load and its movement in relation to the crane, it is also possible to use measurements for determining the orientation of the hoist ropes. The idea of this solution is to minimize the swinging of the load and even to strive to have a transport sequence always begin with an as vertical hoist rope as possible.

Presentation of the problem

[0009] With the present invention, the problems of known solutions can be essentially avoided. The object of the invention is thus to provide an easy to use method and arrangement for controlling a crane with high reliability. This object is achieved in accordance with the invention by giving the method for controlling a crane according to the invention the characterising features of claim 1, while the arrangement for controlling a crane has the characterising features of claim 7. The subsequent dependent claims present appropriate further developments and variations of the invention which further improve its operation.

[0010] The invention is based on the idea of being able to provide an as simple solution as possible in construction and use. This solution should be applicable to both new cranes and cranes that have been used for a short or long period of time.

[0011] In the following, the present invention will be described by illustrating a crane with what is known as a bridge crane. However, this is not intended to limit the invention to this application only, but the method and arrangement for controlling a crane can also be used in cranes of other type, such as building cranes - or tower cranes - container cranes, portal cranes, and gantry cranes of different type.

[0012] In the present invention, "a hoist rope" is the tool, with which the hoist block of the trolley regulates the altitude of the load. It can be a wire, chain or some other suitable auxiliary device that is usually used for this purpose.

[0013] In the following description, the terms "up", "down", "above", "below" and the like refer to directions in relation to an arrangement for controlling a crane or its structural details as shown in the attached figures.

[0014] With the arrangement and method described in the present invention, a plurality of significant advantages are achieved over the prior art. Thus, the transporting of a load in a crane can be controlled in a simple manner that sufficiently prevents the troublesome or even dangerous swinging of the load. The arrangement can without much difficulty and at a reasonable cost be installed in both new cranes and those already in use. The use of the crane also does not require any new control commands, and the crane can continue to be used in the known manner.

[0015] Further advantages and details of the invention become apparent from the description below.

Brief description of the figures

[0016] In the following, the invention will be described in greater detail with reference to the drawing, in which

Figure 1 shows a crane that is movable along guides and equipped with a transverse trolley having a hoist hook,
Figure 2 is a graphical representation of the movements of the trolley and the load it handles,
Figure 3 illustrates the control of the crane,
Figure 4 shows the effect of control on the trolley of the crane,
Figure 5 is a flow chart of a control routine of the crane, and
Figure 6 is a flow chart of an alternative control routine of the crane.

Preferred embodiment

[0017] The above figures do not show the arrangement for controlling a crane or its use in scale but only serve to illustrate structural solutions of the preferred embodiment and the operation of the embodiment. Herein, the respective structural parts shown in the figures and denoted with reference numerals correspond to the structural solutions presented in the description below and which are hereby given their reference numbers.

[0018] A crane 1 is illustrated in the present description and figures as a bridge crane, the structure of which is shown in Figures 1 and 4, in particular. The solutions described in the following can also be applied to cranes and hoist arrangements of other type, in which it is necessary to limit the swinging that occurs in a load when it is moved by the crane.

[0019] Herein, the crane 1 has a main boom 2 that is preferably arranged to be movable in relation to its environment. The bridge crane according to the attached Figures is thus arranged on support members 3, such as beams, which according to Figure 1 are arranged along parallel walls of an industrial facility, for example. Support members of this type can also be arranged one on top of the other in a manner known per se. In other known solutions, the support members can comprise a turnplate to make the main boom of a tower crane turnable in relation to its vertical tower. The support members can further comprise a wheel-mounted portal, for example, that can be driven along horizontal rails or freely along an essentially level base.

[0020] The crane 1 also has at least one trolley 4 arranged to the main boom 2 to be moved along the main boom with at least one drive motor 5 that preferably comprises an inverter-steered stepless electric motor. This trolley, in turn, has a machine-driven hoist block 6 with which the hoist rope 7 and the hoist hook 8 arranged thereto are manoeuvred in a substantially vertical direction. If the main boom is movable in relation to its environment, it also has drive members 9 for moving the main boom along its support member 3.

[0021] So as to steer both the movement of the trolley 4 along the main boom 2 and the movement of the main boom along its support members 3, it is necessary to have a number of measuring elements, such as a speed meter for measuring the speed of the hoist block 6 in relation to its environment. The speed of the hoist block can thus comprise only the movement of the trolley along the main boom, the movement of the main boom along the support members or a combination of the movement of the main boom along the support members and the movement of the trolley along the main boom, of which the latter alternative is shown in Figure 1 and illustrated by arrows B-F and L-R in the Figure. The measuring elements are of a generally known type and not part of the present solution, which is why they are not shown in more detail in the Figures.

[0022] In addition to said speed meters, the trolley 6 of the crane 1 also comprises an angle gauge 10 that is arranged to determine the position of the hoist rope 7 in relation its vertical rest position that is shown by vertical line 11, see Figure 4. The angle gauge preferably measures the angle α of the hoist rope and vertical line in a more or less continuous process. This measuring data is delivered to a regulating unit 12 that can process the data and determine from it the angular speed w of the hoist rope in relation to its vertical rest position and the travel direction of the hoist rope. The angle gauge preferably operates in a three-dimensional measuring space, and the angle gauge can also comprise one or more measuring devices to read deviations in different geometrical directions.

[0023] The regulating unit 12 works together with at least one control unit 13 that is arranged to manoeuvre the drive members 9 or drive motor 5 according to the information it receives from the regulating unit. This way, the same control unit can be arranged to manoeuvre either the drive member or drive motor or both the drive member and drive motor.

[0024] The regulating unit 12 of the crane 1 with the angle gauge 10 coupled thereto make it possible to minimize in a simple and reliable manner the swinging that most often takes place in a load 14 when it is to be transported in a direction that differs from the vertical. The method that is utilized in this control operates in the following manner. Also see Figure 5.

[0025] When a crane user 16 gives a transport command 15 through a control box 17, this means that the angle gauge 10 in the trolley 4 first determines the position of the hoist rope 7 that runs from the trolley and that through the hoist hook 8 arranged thereto can handle loads 14 of different type. The measuring data 18 of the angle gauge concerning the actual position of the hoist rope in relation to its vertical rest position, see vertical line 11, is transmitted to the regulating unit 12 that further determines the angle speed w of the hoist rope and its travel direction in relation to its vertical rest position. If the regulating unit determines that the hoist rope adopts a substantially vertical rest position, a first control signal 19 is given to at least one control unit 13 that forwards the control signal on to regulate only the movement of the trolley 4 along the main boom 2, the movement of the main boom 2 along the support member 3, or a combination of the movement of the main boom along the support member and that of the trolley along the main boom. The control signal results in a substantially stepless acceleration cycle in the drive members or drive motor, when the hoist block reaches a speed that corresponds to half of the maximum speed, which is illustrated by phase I in Figure 2.

[0026] At the same time, observations on the direction of movement and angle position of the hoist rope 7 continue and are continuously forwarded to the regulating unit 12. When the hoist block 6 has reached half of the maximum speed, the measuring values for this time instant are registered. The regulating unit now commands that acceleration be stopped and achieved speed be maintained, which in turn is illustrated by phase II in Figure 2. After this, the continuous observation of the travel direction and angle position of the hoist rope continues. When the hoist rope again takes the same angle position but shows an opposite travel direction in comparison with the registered measuring values above, the drive unit 13 is allowed to transmit a second control signal to the drive members or drive motor. The control signal results in a second substantially stepless acceleration cycle to a speed that corresponds to the maximum speed, which is illustrated by phase III in Figure 2. When this maximum speed has been reached, the regulating unit gives the command to stop acceleration and maintain the reached speed until a new transport command is received, see phase IV in Figure 2.

[0027] Depending on the nature of the movement and transport command 15, the control unit 13 manoeuvres either the drive members 9 or drive motor 5, or both of them.

[0028] The type of manoeuvring of a hoist block 6 described above thus takes place when a load 14 is stationary when movement is about to begin. Often the load already swings when the transport command 15 reaches the regulating unit 12. Alternatively, the load may be stationary but moved in a way that the hoist rope 7 is at an angle in relation to its vertical position. So as to prevent problems that may arise in such situations, the manoeuvring method may be modified to some extent. This modification can be seen in Figure 6 and works in the following way.

[0029] When a crane user 16 gives the transport command 15, the angle gauge 10 first determines the position of the hoist rope 7 in relation to the vertical line 11. If the hoist rope already is at an angle α to its vertical position, the control unit 13 is allowed to transmit the first transport control signal to the drive members 9 or drive motor 5 only after the load 14 (hoist rope) has a travel direction that substantially coincides with a travel direction given in the transport command.

[0030] Like before, this first control signal results in a substantially stepless acceleration cycle that controls the movement of the trolley 4 along the main boom 2, the movement of the main boom along the support members 3, or a combination of the movement of main boom along the support members and the movement of the trolley along the main boom, when the hoist block 6 reaches a speed that corresponds to half the maximum speed (phase I). At the same time, the regulating unit 12 continues to observe the travel direction and angle position of the hoist rope for the purpose of measuring the time T required for the load, after the first control signal has been transmitted, to adopt a travel direction that is opposite to the travel direction given in the transport command 15.

[0031] When the hoist block 6 reaches half the maximum speed, measuring values are again registered for the travel direction w and angle position α of the hoist rope 7. The regulating unit 12 now commands that acceleration be stopped and achieved speed be maintained (phase II). After this, a continuous observation of the travel direction and angle position of the hoist rope continues in such a manner that when the hoist rope adopts an opposite travel direction in relation to the travel direction at the time the transport command 15 was given, the regulating unit waits for a position of the hoist rope that corresponds to the angle at the time when half the maximum speed was reached minus the time (T) multiplied by the angular speed of the hoist rope.

[0032] A second control signal can now be transmitted to the drive members 9 or drive motor 5, which results in a second substantially stepless acceleration cycle to a speed that corresponds to the maximum speed of the hoist block 6 (phase III). When this maximum speed has been reached, the regulating unit again gives the command to stop acceleration and maintain the reached speed until a new transport command is received (phase IV).

[0033] The above description and the related figures are only intended to illustrate the present solution for the construction of an arrangement for controlling a crane or its use. Thus, the solution is not confined merely to the embodiments described above or in the attached claims but a plurality of variations or alternative embodiments is feasible within the idea described in the attached claims.

Claims

1. A method for controlling a crane (1) that comprises a main boom (2),
at least one trolley (4) arranged to the main boom and comprising a drive motor (5) that drives the trolley along the main boom, wherein
the trolley has a machine-driven hoist block (6) for manoeuvring a hoist rope (7) and a hoist hook (8) arranged thereto in a vertical direction, and
at least one speed meter measures the speed of the hoist block in relation to its environment,
an angle gauge (10) that determines the position of the hoist rope (7) in relation to its vertical rest position (11) in such a manner that
the measuring data of the angle gauge is transmitted to the regulating unit (12) that determines the angle speed (w) of the hoist rope and its travel direction in relation to its vertical rest position,
at least one control unit (13) manoeuvres the drive motor (5) in accordance with information received from a regulating unit, whereby
when a given transport command (15) is received, the regulating unit (12) determines the travel direction of the hoist rope (7) so that, if the hoist rope is in a position that differs from its vertical position at the vertical line (11), the control unit (13) is allowed transmit a first control signal to the drive motor (5) only when the load (14) has a travel direction that substantially coincides with a travel direction given in the transport command,
the first control signal resulting in a substantially stepless acceleration cycle that moves the hoist block (6) to a speed that corresponds to half its maximum speed,
characterised in that
the regulating unit (12) measures the time (T) required for the load (14), after the first control signal has been transmitted, to adopt a travel direction that is opposite to the travel direction given in the transport command (15) in such a manner that
when the hoist rope (7) again adopts an opposite travel direction in relation to the travel direction at the time the transport command (15) was given, the regulating unit waits for a position of the hoist rope (7) that corresponds to the angle at the time when half the maximum speed was reached minus the time (T) multiplied by the angular speed (w) of the hoist rope, after which
a second control signal is transmitted to the drive motor (5), which results in a second substantially stepless acceleration cycle to a speed that corresponds to the maximum speed of the hoist block (6).

2. A method for controlling a crane (1) according to claim 1, **characterised in that** the main boom (2) is arranged to be movable in relation to support members (3) by drive members (9), wherein
the control unit (13) manoeuvres the drive members (9) or drive motor (5) in accordance with information it receives from the regulating unit (12).

3. A method for controlling a crane (1) according to claim 2, **characterised in that** the control unit (13) manoeuvres either the drive members (9) or drive motor (5).

4. A method for controlling a crane (1) according to claim 2, **characterised in that** the control unit (13) manoeuvres both the drive members (9) and drive motor (5).

5. An arrangement for controlling a crane (1) that comprises
a main boom (2),
at least one trolley (4) arranged to the main boom (2) and comprising a drive motor (5) that drives the trolley along the main boom, wherein
the trolley has a machine-driven hoist block (6) for manoeuvring a hoist rope (7) and a hoist hook (8) arranged thereto in a vertical direction,
at least one speed meter for measuring the speed of the hoist block, an angle gauge (10) arranged to determine the angle position (α) of the hoist rope (7) in relation to its vertical rest position at the vertical line (11),
a regulating unit (12) arranged to process the data of the angle gauge and to determine the angle speed (w) of the hoist rope and its travel direction in relation to its vertical rest position,
at least one control unit (13) arranged to manoeuvre the drive motor (5) in accordance with information received from the regulating unit.
characterised in that
the drive motor (5) permits a substantially stepless acceleration cycle, and
the regulating unit (12) is arranged to measure the time (T) required for the load (14), after the first control signal has been transmitted, to adopt a travel direction that is opposite to the travel direction given in the transport command (15).

6. An arrangement for controlling a crane (1) according to claim 5, **characterised in that** the crane (1) further comprises support members (3) arranged to receive the main boom (2), and drive members (9) arranged to move the main boom in relation to the support members, wherein the control unit (13) is arranged

to manoeuvre the drive members (9) or drive motor (5) in accordance with information it has received from the regulating unit (12).

7. An arrangement for controlling a crane (1) according to claim 6, **characterised in that** the control unit (13) is arranged to manoeuvre either the drive members (9) or drive motor (5).

8. An arrangement for controlling a crane (1) according to claim 6, **characterised in that** the control unit (13) is arranged to manoeuvre both the drive members (9) and drive motor (5).

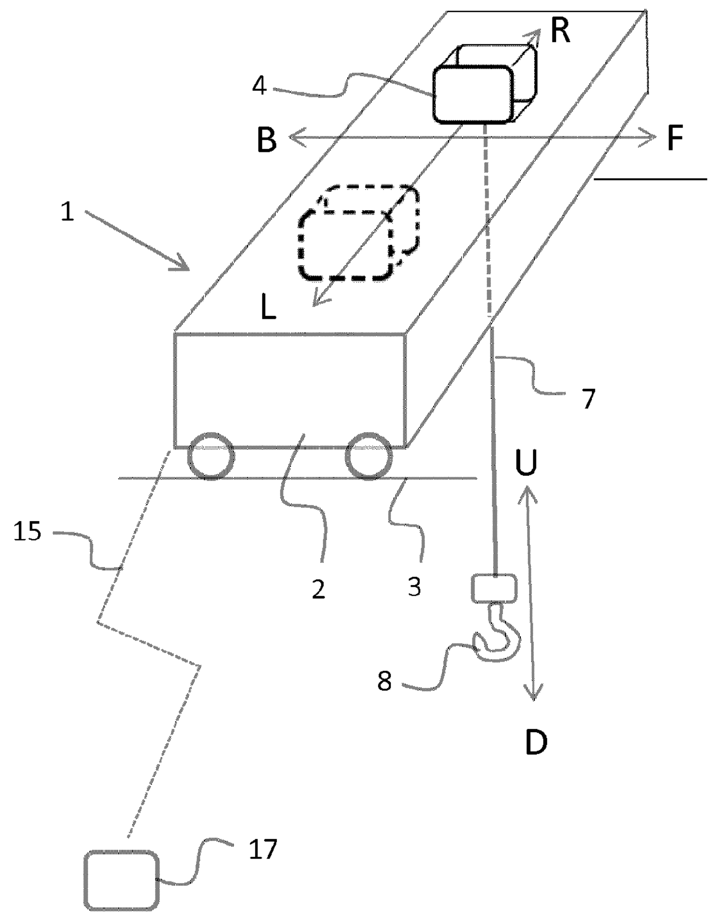
R
4
B
F
1
L
7
U
15
2
3
8
D
17

FIG. 1

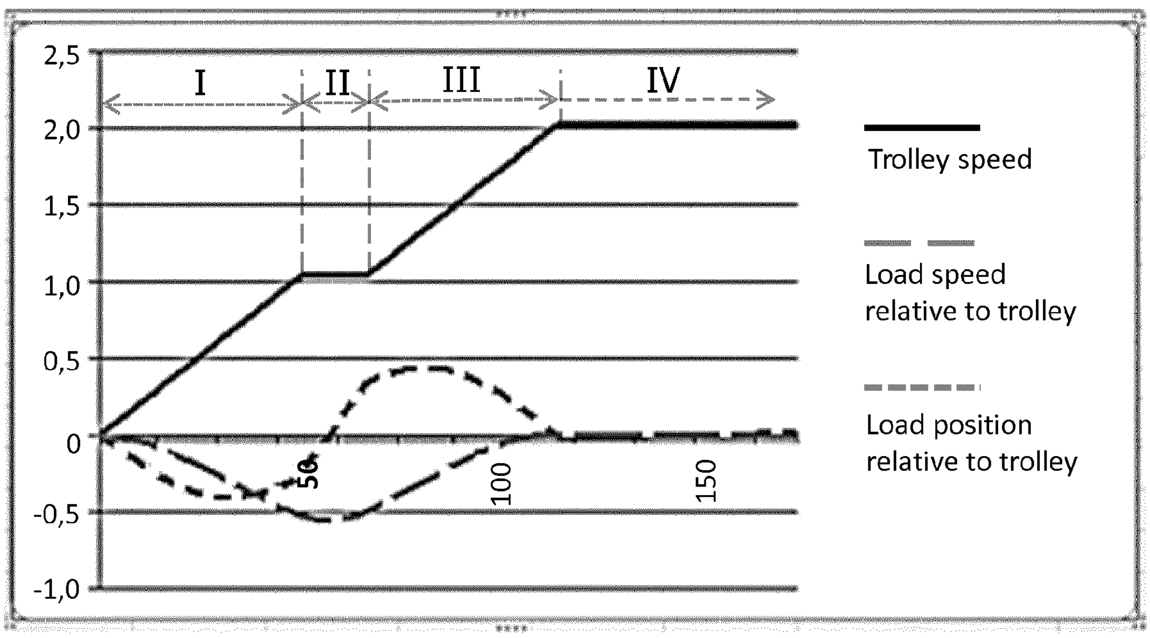
2,5
2,0
1,5
1,0
0,5
0
-0,5
-1,0
I
II
III
IV
50
100
150
Trolley speed
Load speed relative to trolley
Load position relative to trolley

FIG. 2

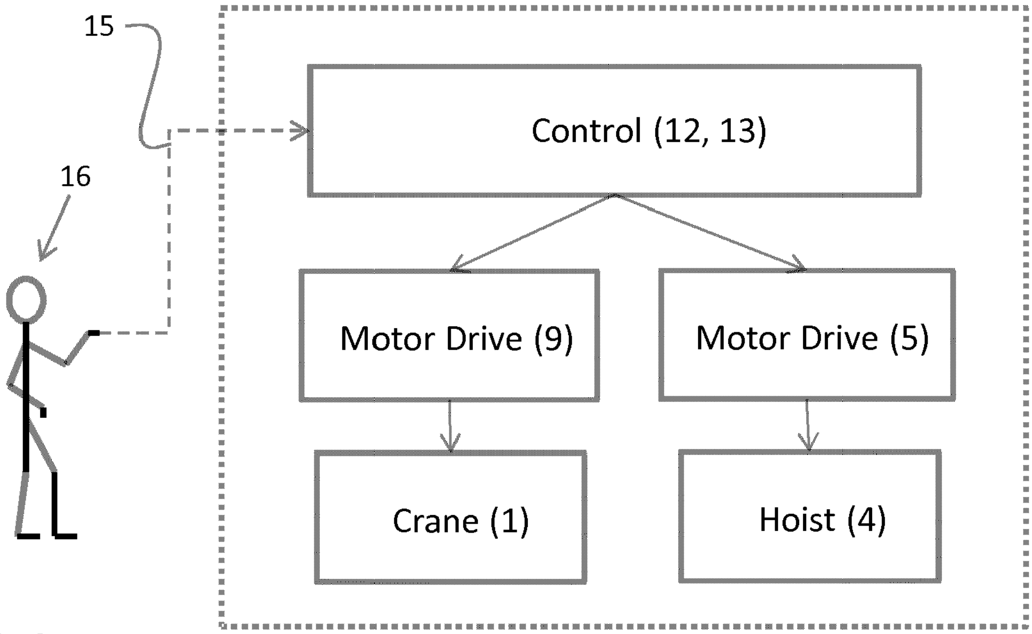
15
16
Control (12, 13)
Motor Drive (9)
Motor Drive (5)
Crane (1)
Hoist (4)

FIG. 3

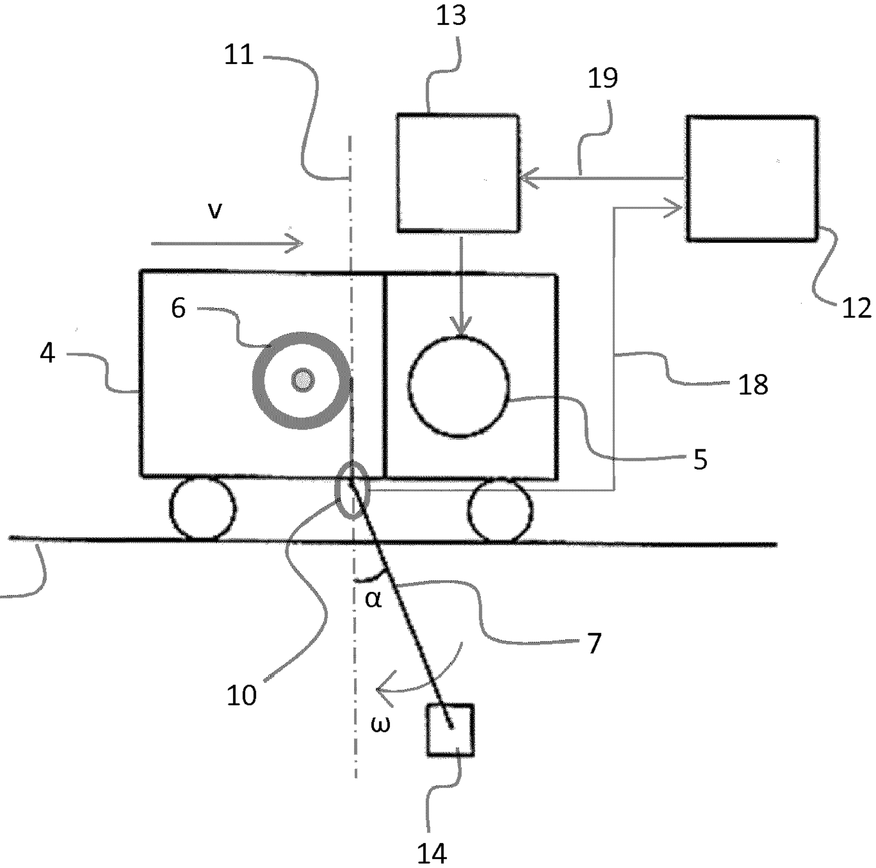
13
11
19
v
6
4
12
18
5
2
10
α
7
ω
14

FIG. 4

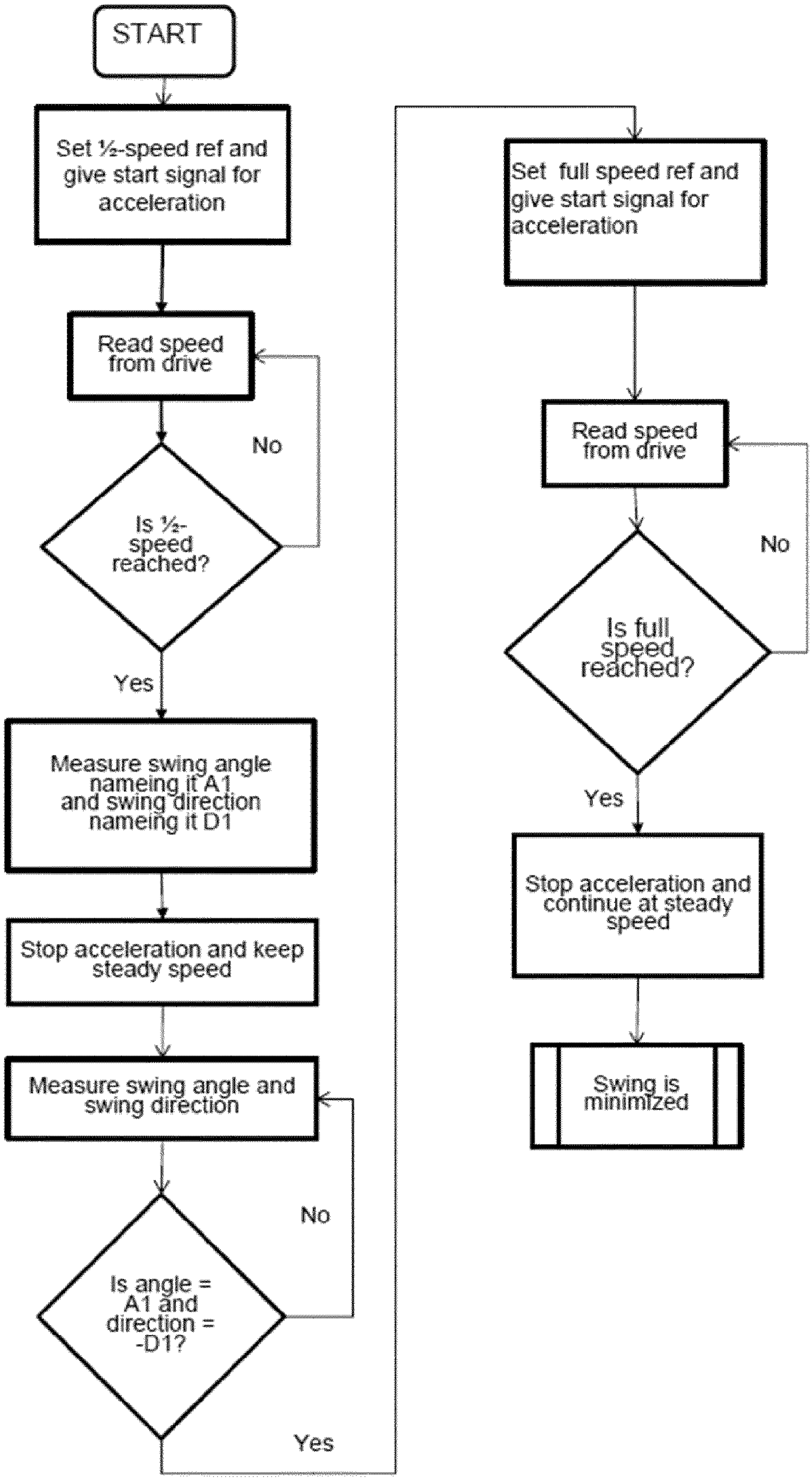
START
Set ½-speed ref and give start signal for acceleration
Read speed from drive
Is ½-speed reached?
No
Yes
Measure swing angle nameing it A1 and swing direction nameing it D1
Stop acceleration and keep steady speed
Measure swing angle and swing direction
Is angle = A1 and direction = -D1?
No
Yes
Set full speed ref and give start signal for acceleration
Read speed from drive
Is full speed reached?
No
Yes
Stop acceleration and continue at steady speed
Swing is minimized

FIG. 5

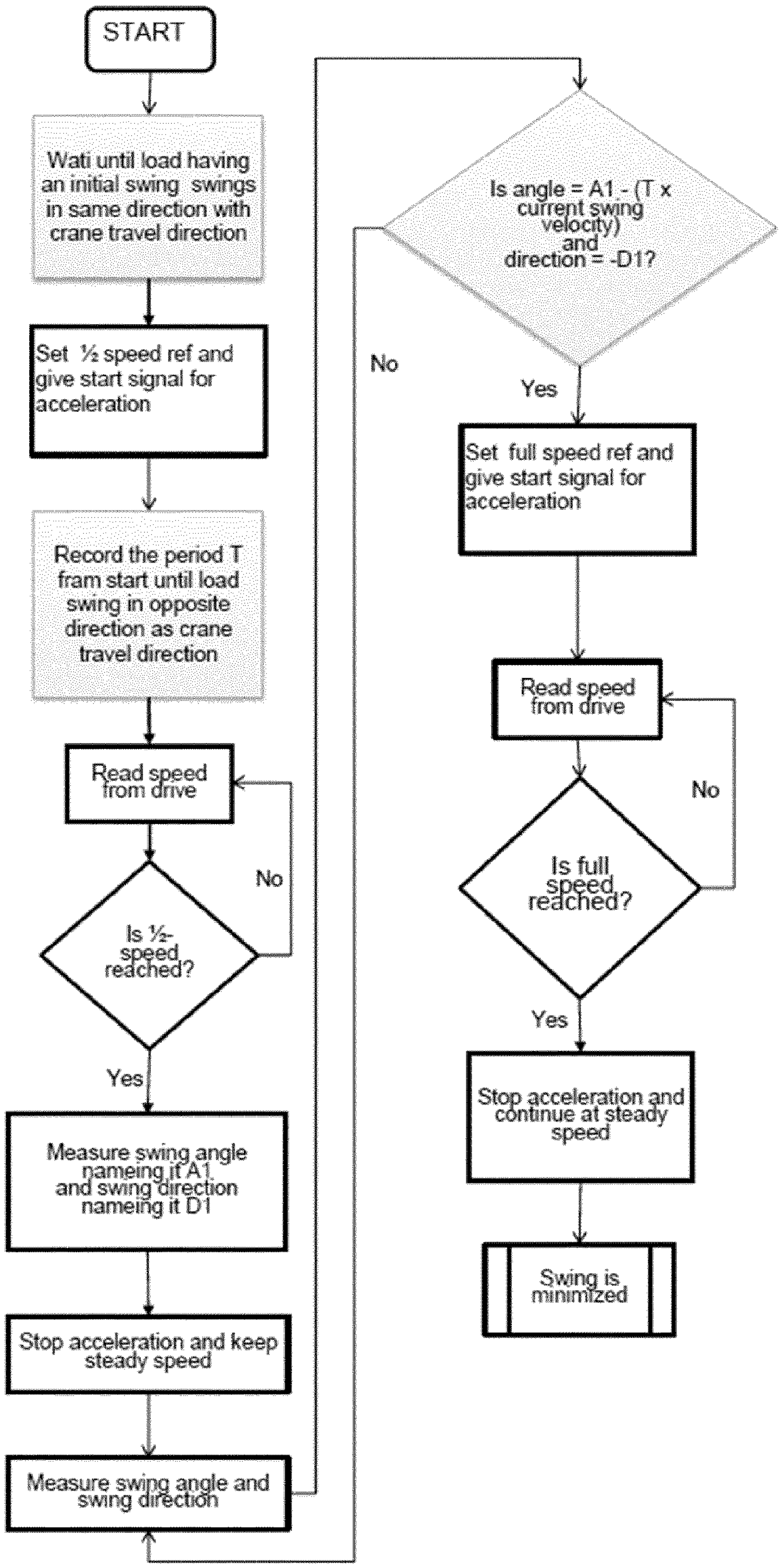
START
Wati until load having an initial swing swings in same direction with crane travel direction
Set ½ speed ref and give start signal for acceleration
Record the period T fram start until load swing in opposite direction as crane travel direction
Read speed from drive
Is ½-speed reached?
No
Yes
Measure swing angle nameing it A1 and swing direction nameing it D1
Stop acceleration and keep steady speed
Measure swing angle and swing direction
Is angle = A1 - (T x current swing velocity) and direction = -D1?
No
Yes
Set full speed ref and give start signal for acceleration
Read speed from drive
Is full speed reached?
No
Yes
Stop acceleration and continue at steady speed
Swing is minimized

FIG. 6

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EUROPEAN SEARCH REPORT

Application Number
EP 15 16 1902

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	DE 11 72 413 B (DEMAG AG) 18 June 1964 (1964-06-18) * column 1, line 46 - column 2, line 42 * * column 3, line 5 - column 4, line 3 * * figures 1,2 *	1-8	INV. B66C13/06
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A,D	US 5 219 420 A (KIISKI TAPANI [FI] ET AL) 15 June 1993 (1993-06-15) * abstract * * figures *	1,5	
A,D	WO 2013/041770 A1 (KONECRANES PLC [FI]) 28 March 2013 (2013-03-28) * abstract *	1,5	TECHNICAL FIELDS SEARCHED (IPC): B66C

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	31 August 2015	Cabral Matos, A

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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L : document cited for other reasons

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EPO FORM 1503 03.82 (P04C01)

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

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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