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(54) **A CRANE ASSEMBLY, AND A METHOD IN RELATION THERETO**

(57) A crane assembly (2) comprising a frame assembly (4) having an elongated extension along a longitudinal axis A, a crane (6) carried by the frame assembly (4), and at least two support legs (8) connected to the frame assembly (4). The crane (6) comprises a column (10), a liftable and lowerable crane boom (12) articulately fastened to the column, and a crane controller (16), which is configured to determine whether one or more predetermined load limiting conditions of the crane assembly (2) are fulfilled for a lifting moment associated with a movement of the crane (6), and to restrict movements of the crane (6) to movements for which the lifting moment of the crane (6) fulfills the load limiting conditions of the

crane assembly (2). The crane controller (16) is further configured to determine a mechanical stress parameter value of the frame assembly (4) as an effect of a lifting moment associated with a movement of the crane (6), wherein at least one load limiting condition specific for the frame assembly (4) is provided that comprises said mechanical stress parameter, and to compare said determined mechanical stress parameter value with a predetermined maximum allowable mechanical stress parameter value of the frame assembly (4), and restrict movements of the crane (6) to movements for which the at least one load limiting condition specific for the frame assembly (4) is fulfilled.

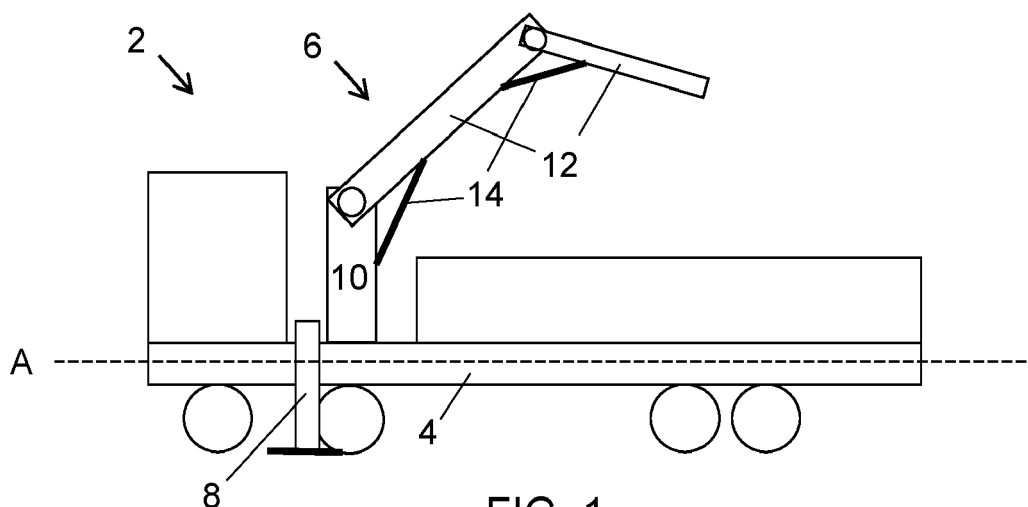


FIG. 1

DescriptionTechnical field

- 5 **[0001]** The present disclosure relates to a crane assembly, and in particular a crane assembly provided with capabilities of adapting crane movements to mechanical parameters of the frame assembly.

Background

- 10 **[0002]** For truck mounted loader cranes, the bending moment at a subframe and a truck chassis is traditionally assumed to be similar to the crane moment. However, this is not always a good enough approximation, in particular for installations where the crane stabilizer system, comprising at least two support legs, are not aligned with the crane slewing axis, i.e. the crane column. This approximation of the bending moment is normally used when dimensioning the subframe for a particular crane installation and the subframes are hence designed assuming that the maximum crane moment is the maximum bending moment that the subframe will hold.

- 15 **[0003]** For some trucks with loader cranes, there are some operational situations that might create large bending effects, but also torsion effects can be considerably large. If all these situations are considered during the subframe calculation for the design of the subframe installation, it may result in that the subframe is heavily over-dimensioned for the most common crane operations.

- 20 **[0004]** Currently, when an accurate calculation study of the installation is done, the subframe should be dimensioned for any possible situation and is thus over-dimensioned for the most common crane operations. However, if these situations are neglected, they can become risky from a structural point of view.

- 25 **[0005]** For heavier cranes, with support legs that are not aligned with the crane column, the approximation of the maximum bending moment needs to be improved to ensure that the subframe is not exposed to excessive bending that it is not dimensioned to withstand. Further, if the subframe instead is dimensioned for the most common crane operations, a less complicated and less expensive subframe is needed, and the weight of the subframe may further be reduced. This will create a more cost-efficient solution but the safety of the installation will then be affected. Thus, an improved solution is hence needed.

- 30 **[0006]** A number of documents within this technical field will now be presented and briefly discussed.

- 30 **[0007]** US6170681B1 discloses a crane having a swing member with a boom mounted on the swing member, wherein the swing member is mounted on the lower frame of the crane and four horizontal protrusion outriggers are mounted on the lower frame of the crane. Further, a load limiting condition is measured according to the position of the crane boom and the outriggers. Also, the movement of the crane is restricted if the condition of load limit is satisfied.

- 35 **[0008]** US4276985A discloses a truck mounted rail crane having a crane and multiple outriggers mounted on a chassis frame. Further, bending or twisting of the chassis frame in accordance to the multiple outriggers is prevented by an interconnection structure of the component to improve the crane boom stability.

- 35 **[0009]** US20070012641A1 discloses a crane comprising at least four movable outriggers in a frame. A column is pivotally mounted on the frame of the truck. Further, it also discloses the measurement of a load limit condition with respect to the position of the boom and the outriggers. Furthermore, if the lifting load exceeds the limiting load value, then the stop signal is sent to stop the operation of the crane.

- 40 **[0010]** JP2003252590A1 discloses an aerial work platform mounted on the body of the vehicle and four outriggers present on the vehicle body. It discloses a rotatable table and a boom mounted on the vehicle body. Also, it discloses that the overturning moment of the boom does not exceed the allowable overturning moment, which prevents the tilting of the boom.

- 45 **[0011]** The object of the present invention is to achieve an improved overload protection capability of a crane assembly, and more particularly to assure structural integrity of the frame assembly of the crane assembly during crane operation.

Summary

- 50 **[0012]** The above-mentioned objects are achieved by the present invention according to the independent claims.

- [0013]** Preferred embodiments are set forth in the dependent claims.

- [0014]** According to one embodiment, a static stress failure mode of the frame assembly is avoided by calculating a bending moment value for those cases in which the traditional approach fails, and stopping the crane movement before reaching a moment above an admissible value, and hence entering a static stress failure mode of the frame assembly.

- 55 **[0015]** According to another embodiment, the calculated bending moment obtained by the above embodiment may further be combined with the torsion moment at the frame assembly, and the crane controller may further be configured monitor the combined stress acting on the frame assembly from both bending and torsion, and stopping the crane before reaching a moment above the admissible value.

[0016] In the traditional approach for estimating the bending moment on a frame assembly for a loader crane mounted to a truck, it is assumed that the crane column is aligned with one pair of the support legs, but the inventor has found that this approach may fail and then lead to severe consequences, in particular for heavy cranes.

[0017] By implementing the present invention, a more accurate approximation of the bending moment will be achieved, that further will enable a better fit of the dimensioning of the frame assembly for a particular crane installation. There will hence be less need to over-dimension the subframe to be on the safe side, and it will be ascertained that the maximum allowed mechanical stress parameter of the frame assembly will not be exceeded.

[0018] In particular, by implementing the present invention it will be possible to optimize the cost and weight of the subframe for big cranes (>50Tm) for the application, while maintaining the safety. The advantages with the invention will be even more significant for cranes above 90 Tm.

Brief description of the drawings

[0019]

Figure 1 is a schematic side view of a loader vehicle provided with a crane assembly according to the present invention.

Figure 2 is a block diagram illustrating the crane controller according to the present invention.

Figure 3 shows two graphs illustrating bending moments of different crane set-ups.

Figures 4 and 5 are schematic top views of a vehicle provided with a crane assembly according to embodiments of the present invention.

Figure 6 is a schematic top view of a vehicle illustrating torsion moment applied in embodiments according to the present invention.

Figures 7A-7D are schematic top views of a vehicle, illustrating various aspect of determining torsion moment applied in embodiments according to the present invention.

Figure 8 is a flow diagram illustrating the method according to the present invention.

figure 9 is a flow diagram illustrating the method according the present invention in more detail.

Detailed description

[0020] The crane assembly, and a method of the crane assembly, will now be described in detail with references to the appended figures. Throughout the figures, the same, or similar, items have the same reference signs. Moreover, the items and the figures are not necessarily to scale, emphasis instead being placed upon illustrating the principles of the invention.

[0021] In one conventional application, loader cranes comprising a crane assembly as defined herein are normally mounted on trucks. These trucks often are manufactured by a truck manufacturer for a general purpose, i.e. the same truck could be used to carry just a load platform, or other kind of body on it. The main structural component of a truck is normally denoted a chassis. Conventionally it comprises two longitudinal beams and cross members and it holds all the other truck elements (engine, gearbox, suspension, cabin, etc...). A chassis may also be the name of an unfinished truck (without body), as it is supplied from the truck manufacturer factory that cannot carry any load or be used for anything, as it is an incomplete vehicle. Very often, truck manufacturers call the main structural component of a truck "frame". A truck chassis is completed by a "bodybuilder", which is another company, which makes the "body", so the truck is completed and can transport goods. The structural part of this body is often called "subframe".

[0022] When the truck is equipped with a loader crane, the subframe must be designed in accordance with the instructions in the installation manual of the loader crane manufacturer.

[0023] The mechanical efforts like forces and moments (mainly bending and torsion moments) generated by the crane are (normally) held by the assembly of the chassis (or the frame) and the subframe. These mechanical efforts produce a stress distribution at the structure (frame + subframe) depending on the mechanical properties of their elements, and the subframe attachment type (i.e. the way the subframe is attached to the chassis/frame).

[0024] Thus, herein the expression frame assembly is defined as the combined structural entity comprising a subframe and a main frame (chassis), where the subframe is attached to the main frame. The main frame is the main structural component of a vehicle and has an elongated extension. A loader crane may be mounted on the subframe.

[0025] With references to figures 1 and 2, the present disclosure relates to a crane assembly 2 comprising a frame assembly 4 having an elongated extension along a longitudinal axis A, a crane 6 carried by the frame assembly 4, and at least two support legs 8 connected to the frame assembly 4. The respective support leg 8 is maneuverable to an active support position in contact with the ground.

[0026] The crane assembly is typically arranged at a vehicle as schematically illustrated in figure 1 and may be provided with a cargo platform to/from which loads may be loaded/unloaded by the crane.

[0027] The crane 6 comprises a column 10, which is rotatable in relation to the frame assembly 4 about an essentially

vertical axis; a liftable and lowerable crane boom 12 articulately fastened to the column, and at least one lifting cylinder 14, for lifting and lowering the crane boom 12 in relation to the column 10. Further crane booms, such as telescopic booms, may further be mounted to the crane boom, and various crane tools such as hooks, grapples, forks etc. may be mounted to the crane tip.

[0028] The crane 6 further comprises a crane controller 16. The crane controller 16 is provided with processing, controlling, and calculation capabilities to control and monitor all various functions of the crane, and also communication capabilities required to communicate with control units of e.g. a vehicle where the crane is mounted, and/or remote entities such as crane owners. The crane controller 16 may be embodied as one single unit or by several units.

[0029] The crane controller 16 is configured to determine whether one or more predetermined load limiting conditions of the crane assembly 2 are fulfilled for a lifting moment associated with a movement of the crane 6. The crane controller is further configured to restrict movements of the crane 6 to movements for which the lifting moment of the crane 6 fulfills the one or more load limiting conditions of the crane assembly 2. This is performed e.g. in order to prevent the crane assembly from tipping during operation.

[0030] In order to restrict movements of the crane 6, the crane controller 16 is configured to determine and to generate a plurality of control signals to be applied to the crane 6, e.g. to the lifting cylinders 14, which is schematically illustrated in figure 2 by a block arrow.

[0031] As an example, the crane controller 16 may estimate the current lifting moment of the crane by monitoring the force applied by a main actuator for the lifting of the load with the crane. In a truck mounted crane, the main actuator is typically responsible for lifting the crane arm including the load relative to the vertical crane column. If a hydraulic main lifting cylinder is used for the crane then the pressure of the corresponding lifting cylinder may be used in the estimations.

[0032] The crane controller 16 is further configured to determine a mechanical stress parameter value of the frame assembly 4 as an effect of a lifting moment associated with a movement of the crane 6. When determining the mechanical stress parameter value, relative positions along the longitudinal axis A of at least one of the support legs 8 and the column 10 of the crane 6 are considered.

[0033] At least one load limiting condition specific for the frame assembly 4 is provided that comprises the mechanical stress parameter, and wherein the at least one load limiting condition is based on properties of the crane assembly 2.

[0034] Furthermore, the crane controller is configured to compare the determined mechanical stress parameter value with a predetermined maximum allowable mechanical stress parameter value of the frame assembly 4, which e.g. is determined during installation of the crane assembly.

[0035] The crane controller is also configured to restrict movements of the crane 6 to movements for which the at least one load limiting condition specific for the frame assembly 4 is fulfilled.

[0036] One load limiting condition specific for the frame assembly 4 to be fulfilled, is that the result of the comparison is that the determined mechanical stress parameter value is lower than the predetermined maximum allowable mechanical stress parameter value.

[0037] Specifically, the "load limiting conditions for the crane assembly" addresses the stability during the crane operation, i.e. prevents the crane installation from tipping over during operation, where as the "load limiting condition specific for the frame assembly" addresses the mechanical stress that is put on the frame assembly due to crane operation, and defines a static stress failure mode, being checked when doing a static calculation. Thus, this "load limiting condition specific for the frame assembly" defines that the static stress failure mode should be avoided for the frame assembly during crane operation.

[0038] According to one embodiment, the mechanical stress parameter is dependent on a calculated bending moment of the frame assembly 4, and the mechanical properties of the frame assembly 4. This embodiment will now be discussed in detail.

[0039] Preferably, it is assumed herein that the support legs carry most of the weight, with only negligible weight laying on the wheels of the vehicle. This approach is hence mainly valid for heavy range cranes of a capacity higher than 50Tm.

[0040] As earlier described the traditional approach is to assume that the maximum bending moment exerted on the chassis is similar to the maximum moment of the crane ("Crane M") which would take place when the crane is pointing to the rear of the truck with the support legs aligned with the crane column.

[0041] When the crane column is not aligned with the support legs, the maximum bending moment that may be exerted on the frame assembly is however larger than the maximum moment of the crane ("Crane M"). The reason is that there is an additional "Extra Moment" ("Extra M"), which is schematically illustrated in the right part of figure 3.

[0042] The left part of figure 3 shows the traditional case where the support legs are aligned with the crane column, and the right part of the figure shows the case for heavy range cranes with stabilizers (support legs) not aligned with the crane column.

[0043] This "Extra M" value originates from the load on the main support legs and its distance to the crane column ("a"). Vertical reactions on support legs will always have a positive value and increased rear stability implies more "Extra M", so the worst conditions from this point of view are:

- Long and heavy trucks,
- Crane working in short outreach, and
- Heavy load on the truck.

[0044] Thus, the "Extra M" may be estimated from the reactions and distances to the stabilizer legs, as illustrated in figure 3

[0045] Currently, subframes are dimensioned/calculated assuming that the maximum crane moment is the maximum bending moment that the subframe/chassis will hold. However, this is not necessarily the case as outlined above.

[0046] This embodiment according to the present invention will ensure that the frame assembly is not exposed to higher bending moments than it is designed for. It could both avoid over-dimensioning the subframe (which is normally the way to tackle the present poor estimations of the actual stresses due to e.g. bending that the frame assembly needs to handle during crane operation) as well as improve the safety when working with the crane.

[0047] As outline above, the present invention is directed to a crane assembly comprising a frame assembly, a crane carried by the frame assembly and at least two support legs, conventionally four or more (at least for the heavier type of cranes), connected to the frame assembly. The respective support leg is manoeuvrable to an active support position in contact with the ground. The crane assembly may be mounted to a vehicle, such as a truck, and the frame assembly may refer to the subframe for the crane alone, or a combination with a frame of the vehicle.

[0048] According to this embodiment, the mechanical stress parameter is dependent on a calculated bending moment of the frame assembly 4, which adds on a further load limiting condition specific for the frame assembly defining that a static stress failure mode should be avoided for the frame assembly during crane operation. The bending moment for a particular slewing angle α may then be estimated as illustrated in figure 4.

[0049] The real and current bending moment of a calculation cross-section of the frame assembly denoted CUT1 is calculated by the following formula (this true when CUT1 is at the crane column, which is where the bending moment is at its maximum and is hence corresponding to the worst-case scenario):

$$M(\text{CUT1}) = [M_c \times \cos(\alpha)] + [R_a(l) \times D(l)] + [R_a(r) \times D(r)]$$

[0050] Where α is the current slewing angle of the crane boom, M_c is the moment at the position of the crane column, $R_a(l)$ and $R_a(r)$ are reaction forces at the ground by left and right support legs from axis A for the respective left and right front support legs, and $D(l)$ and $D(r)$ are distances along the longitudinal axis A of the respective left and right front support legs.

[0051] This calculated bending moment, considering the placement of the stabilizers mounted behind the truck cab but in front of the crane column (these may be referred to as the main stabilizers) relative to the crane column, is then to be compared to a corresponding maximum bending moment value that the frame assembly has been designed to last. If the estimated bending moment is larger than the corresponding maximum bending moment value then this movement of the crane should not be allowed by the crane controller. When estimating the bending moment, the actual load on the support legs may further be considered. This may e.g. be deduced from pressures in the cylinders of the support legs. As earlier described, the mechanical stress parameter is a function of the mechanical efforts (like the moment resulting from the crane installation and operation) and the mechanical properties of the structure it is applied to. The calculation cut is defining where the calculation is made along the structure and the efforts as well as the mechanical properties may vary along the structure (see figure 3 for how the moment is varying along the frame assembly). The mechanical properties may also vary along the frame assembly, e.g. by having a larger thickness of the steel plates where the moment is large. One or more load limiting conditions for the frame assembly may set up addressing one or more positions along the assembly. With a calculation cut at the crane column the bending moment will be at its maximum which corresponds to an embodiment of the invention. This may be advantageous as this gives a worst-case scenario for the load limiting condition specific for the frame assembly. In an alternative embodiment the bending moment at its maximum, at the cut corresponding to the crane column, may be combined with the mechanical properties of another point along the frame assembly. For example, by combining the maximum moment with mechanical properties at a point where the frame assembly is weaker a safety margin may be added in the condition.

[0052] According to another embodiment, the mechanical stress parameter is dependent on a combination of calculated bending and torsion moments of the frame assembly 4, and the mechanical properties of the frame assembly 4.

[0053] This embodiment will now be discussed in detail.

[0054] The crane assembly according to this embodiment and defined herein would make sure that the limitations set by the properties of the frame assembly, as estimated based on the individual installation and geometry of the crane assembly with the frame assembly, crane and stabilizers, are not exceeded. This increases the safety with lighter and more cost-efficient structures, which would otherwise risk to be damaged in specific use cases.

[0055] At least one calculation point for the calculations at the frame assembly is needed, which, in the schematic

illustration shown in figure 5, is defined by the calculation cut.

[0056] The Von Mises Stress (σ_{VM}), which defines the combined stress due to the bending and the torsion in this case, may be used to define a load limiting condition specific for the frame assembly defining that a static stress failure mode should be avoided for the frame assembly during crane operation. The normal, horizontal bending and horizontal and vertical shear stresses may be considered to be negligible. The normal stress due to the vertical bending is here denoted σ and the shear stress due to torsion is denoted T .

[0057] Before going further, a short description of the so-called von Mises yield criterion will be given.

[0058] In materials science and engineering the von Mises yield criterion can also be formulated in terms of the von Mises stress or equivalent tensile stress. This is a scalar value of stress that can be computed from the Cauchy stress tensor. In this case, a material is said to start yielding when the von Mises stress reaches a value known as yield strength, σ . The von Mises stress is used to predict yielding of materials under complex loading from the results of uniaxial tensile tests. The von Mises stress satisfies the property where two stress states with equal distortion energy have an equal von Mises stress.

[0059] Thus, figure 5 is a schematic diagram of a crane assembly 2 illustrating the calculation cut and the slewing angle α of the crane.

[0060] The combined bending and torsion stresses may then be estimated and monitored by the crane controller using the load limiting condition specific for the frame assembly defining that a static stress failure mode should be avoided for the frame assembly during crane operation. Crane movements that would result in an estimation of the combined bending and torsion stress that exceeds the maximum allowable limit, would be stopped by the crane controller as a safety measure.

[0061] It is an advantage to base the overload protection system for the frame assembly according to this embodiment of the present invention on a combined measure of the bending and torsion effects, such as the von Mises stress. The reason is that the slewing angle, α , of the crane has influence in bending and torsion. If handled separately, the admissible torsion and bending at the frame assembly will be different for different α :

- For an α close to 90° , the bending will be very small, so most of the σ_{VM} will be generated by the torsion, so the frame assembly will be able to hold a big torsional moment.
- For an α close to 0° , the bending will be very big, so most of the σ_{VM} will be generated by the bending, so the frame assembly will be able to hold a small torsional moment.

[0062] The value of σ is obtained from the bending moment and the mechanical properties of the calculation cut.

[0063] The bending moment can be obtained from the current crane moment $\times \cos(\alpha)$, or, as explained above in connection with the embodiment where the bending moment is applied (that is more accurate for crane installations where the main support legs are not aligned with the crane column).

[0064] The value τ is obtained from the frame assembly torsion moment and the mechanical properties of the calculation cut.

[0065] Figure 6 is a schematic view from above illustrating torsion moments T_1 , T_2 , and T_3 along the longitudinal axis A of the crane assembly A.

[0066] There exist various exemplary alternatives for estimating the torsion moment at the frame assembly for an integrated stabilizer system. For these calculations the front wheels are assumed to be off ground and the front of the truck would hence be supported by the main support legs, resulting in that T_1 in figure 6 is assumed to be 0.

[0067] Depending on the choice of methodology for calculating the torsion moment at the frame assembly, additional sensors may or may not be required compared to what is available in today's cranes. In some alternatives, forces are calculated based upon measurement values from pressure sensors of the support legs.

[0068] In a further alternative variation, inclination sensors are applied which are arranged on the longitudinal axis of the crane assembly, and further on support legs.

[0069] The alternative with the inclination sensors is further explained with reference to figures 7A-7D, where figures 7A and 7B focus on a crane installation with an integrated stabilizer system and figures 7C and 7D disclose a crane installation without an integrated stabilizer system. In the figures, a double arrow directed upwards indicates an inclination sensor adapted to measure transversal inclination, and a double arrow directed to the right indicates an inclination sensor adapted to measure longitudinal inclination.

[0070] The inclination sensors will give an estimation of the twisting of the frame assembly from transversal and longitudinal inclination measurements. As examples, the longitudinally oriented sensors (1A, 2A, 3A) measure transversal inclination. The measurements from 1A and 1B are combined to have the total inclination of the crane base, of course other more advanced sensor(s) would also be an alternative.

[0071] The best placements for the tilting sensors would be close to the slewing system of the crane (see figures 7A and 7C, sensors 1A and 1B). In order to determine the subframe twisting that then may be used to calculate the torsional moment at the subframe, the relative transversal angle between crane and auxiliary rear support legs needs further to

be measured, especially for cranes with an integrated stabilizer system in the crane base. For this, two tilting sensors are required (see figure 7B, sensors 1A and 2A).

[0072] For cranes in which their base does not have an integrated stabilizer system, there are two subframe sectors which suffer of a different torsion/twisting values that implies that three tilting sensors are needed to determine the torsion moment in each subframe sector (see figure 7D, sensors 1A, 2A, and 3A).

[0073] In figure 7B the relative angle (only the transversal) between the crane base and auxiliary stabilizer is measured. The torsion moment at the subframe is calculated using twisting angle, subframe torsional stiffness, and subframe length.

[0074] In figure 7D the relative angle (only the transversal) between the crane base and auxiliary stabilizer is measured. The torsion moment at the subframe is calculated using twisting angles, subframe torsional stiffnesses, and subframe lengths.

[0075] In a further embodiment, the crane controller 16 is configured to determine the torsion moment of the frame assembly 4 by applying measurement values from at least one pressure sensor 18 of the support legs 8 and/or at least one inclination sensor 20 arranged along the longitudinal axis A. This is schematically illustrated in figure 2.

[0076] Thus, to summarize the embodiment described above, the crane controller 16 is configured to determine the mechanical stress parameter being a combination of bending and torsion moments of the frame assembly 4 by applying Von Mises Stress (σ_{VM}) calculations, which define the combined stress due to the bending and the torsion to be used to define a load limiting condition specific for the frame assembly defining that a static stress failure mode should be avoided for the frame assembly during crane operation for the frame assembly 4.

[0077] According to a further embodiment, the crane controller 16 is configured to determine the mechanical stress parameter when at least two of the support legs 8 are in their active support positions.

[0078] In another embodiment, the frame assembly 4 comprises a main frame of a vehicle and a subframe attached to the main frame.

[0079] The present invention also relates to a method of a crane assembly 2. The crane assembly has been described in detail above and it is herein referred to that description. The method will now be described with references to the flow diagrams shown in figure 8 and figure 9. The flow diagram in figure 8 comprises an overview illustration of the method, whereas figure 9 is a more detailed illustration of the method according the present invention.

[0080] As described in detail above, the crane assembly 2 comprises a frame assembly 4 having an elongated extension along a longitudinal axis A, a crane 6 carried by the frame assembly 4, and at least two support legs 8 connected to the frame assembly 4. The respective support leg 8 is maneuverable to an active support position in contact with the ground, and the crane 6 comprises a crane controller 16.

[0081] The method of the crane assembly comprises:

- determining whether one or more predetermined load limiting conditions of the crane assembly 2 are fulfilled for a lifting moment associated with a movement of the crane 6, and
- restricting movements of the crane 6 to movements for which the lifting moment of the crane 6 fulfills the load limiting conditions of the crane assembly 2.

[0082] This method steps prevent the crane from e.g. enter the static stress failure mode for the frame assembly during a lifting procedure.

[0083] The method further comprises:

- determining a mechanical stress parameter value of the frame assembly 4 as an effect of a lifting moment associated with a movement of the crane 6, wherein relative positions along said longitudinal axis A of at least one of the support legs 8 and the column 10 of the crane 6 is taken into account when determining said mechanical stress parameter value, and that at least one load limiting condition specific for the frame assembly 4 is provided that comprises said mechanical stress parameter, and wherein said at least one load limiting condition is based on properties of the crane assembly 2.

[0084] In this step, a mechanical stress parameter value of the frame assembly is determined.

[0085] The method continues by the following steps:

- comparing said determined mechanical stress parameter value with a predetermined maximum allowable mechanical stress parameter value of the frame assembly 4, and
- restricting movements of the crane 6 to movements for which the at least one load limiting condition specific for the frame assembly 4 is fulfilled, wherein one load limiting condition specific for the frame assembly 4 to be fulfilled, is that the result of said comparison is that said determined mechanical stress parameter value is lower than said predetermined maximum allowable mechanical stress parameter value.

[0086] In the following, some embodiments of the method are listed. These have the same technical features and advantages as for the corresponding features of the crane assembly described above. Consequently, these technical features and advantages are not repeated or explained anew in order to avoid unnecessary repetition.

[0087] According to one embodiment, the method comprises that the mechanical stress parameter is dependent on a calculated bending moment of the frame assembly 4. It is described in detail above how this calculation may be performed.

[0088] According to another embodiment, the method comprises that the mechanical stress parameter is dependent on a combination of calculated bending and torsion moments of the frame assembly 4. It is described in detail above how this calculation may be performed.

[0089] According still another embodiment, the method comprises determining the torsion moment of the frame assembly 4 by applying measurement values from at least one pressure sensor 18 of the support legs 8 and/or at least one inclination sensor 20 arranged along the longitudinal axis A.

[0090] In a further embodiment, the method comprises determining the mechanical stress parameter being a combination of bending and torsion moments of the frame assembly 4 by applying Von Mises Stress (σ_{VM}) calculations, which define the combined stress due to the bending and the torsion to be used to define a load limiting condition specific for the frame assembly defining that a static stress failure mode should be avoided for the frame assembly during crane operation.

[0091] Preferably, the method comprises determining the mechanical stress parameter when at least two of said support legs 8 are in their active support positions.

[0092] Advantageously, the frame assembly 4 comprises a main frame of a vehicle and a subframe attached to the main frame.

[0093] The present invention is not limited to the above-described preferred embodiments. Various alternatives, modifications and equivalents may be used. Therefore, the above embodiments should not be taken as limiting the scope of the invention, which is defined by the appending claims.

Claims

1. A crane assembly (2) comprising a frame assembly (4) having an elongated extension along a longitudinal axis A, a crane (6) carried by the frame assembly (4), and at least two support legs (8) connected to the frame assembly (4), the respective support leg (8) is maneuverable to an active support position in contact with the ground, wherein the crane (6) comprises:

- a column (10), which is rotatable in relation to the frame assembly (4) about an essentially vertical axis;
- a liftable and lowerable crane boom (12) articulately fastened to the column;
- at least one lifting cylinder (14), for lifting and lowering the crane boom (12) in relation to the column (10), and
- a crane controller (16), which is configured to determine whether one or more predetermined load limiting conditions of the crane assembly (2) are fulfilled for a lifting moment associated with a movement of the crane (6), and to restrict movements of the crane (6) to movements for which the lifting moment of the crane (6) fulfills the load limiting conditions of the crane assembly (2), **characterized in that** said crane controller (16) is further configured to:
 - determine a mechanical stress parameter value of the frame assembly (4) as an effect of a lifting moment associated with a movement of the crane (6), wherein relative positions along said longitudinal axis A of at least one of the support legs (8) and the column (10) of the crane (6) is taken into account when determining said mechanical stress parameter value, and that at least one load limiting condition specific for the frame assembly (4) is provided that comprises said mechanical stress parameter, and wherein said at least one load limiting condition is based on properties of the crane assembly (2);
 - compare said determined mechanical stress parameter value with a predetermined maximum allowable mechanical stress parameter value of the frame assembly (4), and
 - restrict movements of the crane (6) to movements for which the at least one load limiting condition specific for the frame assembly (4) is fulfilled, wherein one load limiting condition specific for the frame assembly (4) to be fulfilled, is that the result of said comparison is that said determined mechanical stress parameter value is lower than said predetermined maximum allowable mechanical stress parameter value.

2. The crane assembly (2) according to claim 1, wherein said mechanical stress parameter is dependent on a calculated bending moment of the frame assembly (4).

3. The crane assembly (2) according to claim 1, wherein said mechanical stress parameter is dependent on a combi-

nation of calculated bending and torsion moments of the frame assembly (4).

4. The crane assembly (2) according to claim 3, wherein the crane controller (16) is configured to determine the torsion moment of the frame assembly (4) by applying measurement values from at least one pressure sensor (18) of said support legs (8) and/or at least one inclination sensor (20) arranged along said longitudinal axis A.

5. The crane assembly (2) according to claim 3 or 4, wherein the crane controller (16) is configured to determine said mechanical stress parameter being a combination of bending and torsion moments of the frame assembly (4) by applying Von Mises Stress (σ_{VM}) calculations, which define the combined stress due to the bending and the torsion to be used to define a load limiting condition specific for the frame assembly defining that a static stress failure mode should be avoided for the frame assembly during crane operation.

6. The crane assembly (2) according to any of claims 1-5, wherein said crane controller (16) is configured to determine said mechanical stress parameter when at least two of said support legs (8) are in their active support positions.

7. The crane assembly (2) according to any of claims 1-6, wherein said frame assembly (4) comprises a main frame of a vehicle and a subframe attached to the main frame.

8. A method of a crane assembly (2) comprising a frame assembly (4) having an elongated extension along a longitudinal axis A, a crane (6) carried by the frame assembly (4), and at least two support legs (8) connected to the frame assembly (4), the respective support leg (8) is maneuverable to an active support position in contact with the ground, and the crane (6) comprises a crane controller (16), wherein the method comprises:

- determining whether one or more predetermined load limiting conditions of the crane assembly (2) are fulfilled for a lifting moment associated with a movement of the crane (6), and
- restricting movements of the crane (6) to movements for which the lifting moment of the crane (6) fulfills the load limiting conditions of the crane assembly (2),

characterized in that the method further comprises:

- determining a mechanical stress parameter value of the frame assembly (4) as an effect of a lifting moment associated with a movement of the crane (6), wherein relative positions along said longitudinal axis A of at least one of the support legs (8) and the column (10) of the crane (6) is taken into account when determining said mechanical stress parameter value, and that at least one load limiting condition specific for the frame assembly (4) is provided that comprises said mechanical stress parameter, and wherein said at least one load limiting condition is based on properties of the crane assembly (2);
- comparing said determined mechanical stress parameter value with a predetermined maximum allowable mechanical stress parameter value of the frame assembly (4), and
- restricting movements of the crane (6) to movements for which the at least one load limiting condition specific for the frame assembly (4) is fulfilled, wherein one load limiting condition specific for the frame assembly (4) to be fulfilled, is that the result of said comparison is that said determined mechanical stress parameter value is lower than said predetermined maximum allowable mechanical stress parameter value.

9. The method according to claim 8, wherein said mechanical stress parameter is dependent on a calculated bending moment of the frame assembly (4).

10. The method according to claim 8, wherein said mechanical stress parameter is dependent on a combination of calculated bending and torsion moments of the frame assembly (4).

11. The method according to claim 10, comprising determining the torsion moment of the frame assembly (4) by applying measurement values from at least one pressure sensor (18) of said support legs (8) and/or at least one inclination sensor (20) arranged along said longitudinal axis A.

12. The method according to claim 10 or 11, comprising determining said mechanical stress parameter being a combination of bending and torsion moments of the frame assembly (4) by applying Von Mises Stress (σ_{VM}) calculations, which define the combined stress due to the bending and the torsion to be used to define a load limiting condition specific for the frame assembly defining that a static stress failure mode should be avoided for the frame assembly during crane operation.

13. The method according to any of claims 8-12, comprising determining said mechanical stress parameter when at least two of said support legs (8) are in their active support positions.
- 5 14. The method according to any of claims 8-13, wherein said frame assembly (4) comprises a main frame of a vehicle and a subframe attached to the main frame.

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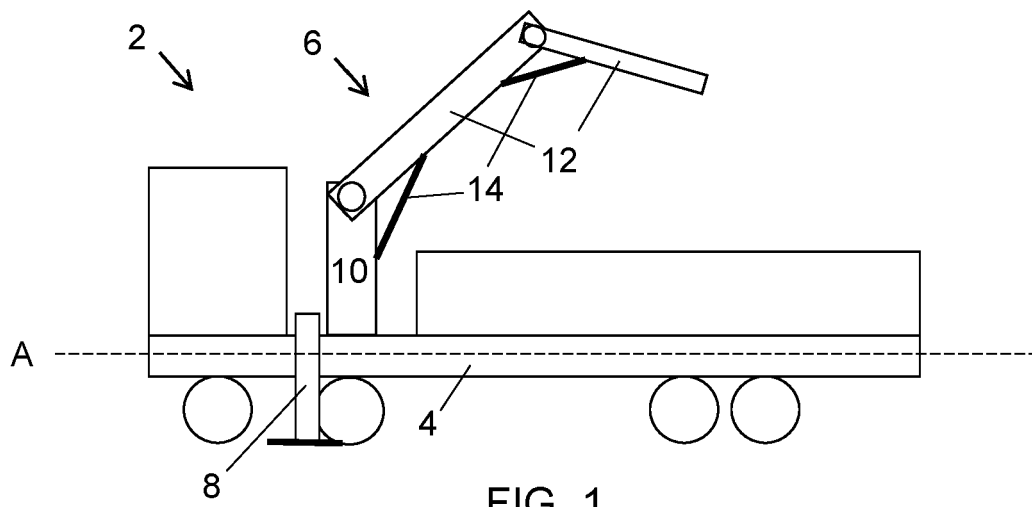


FIG. 1

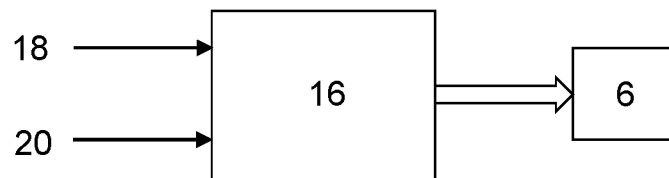


FIG. 2

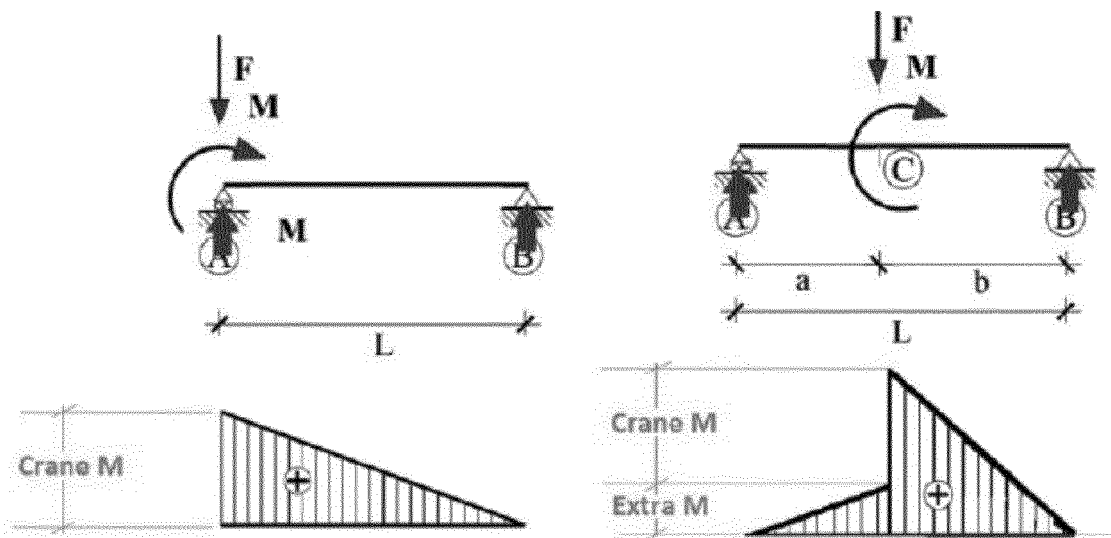


FIG. 3

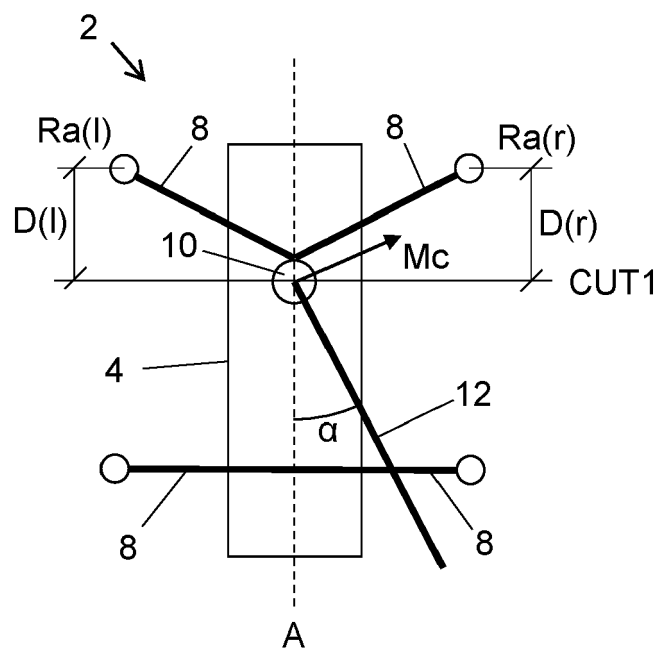


FIG. 4

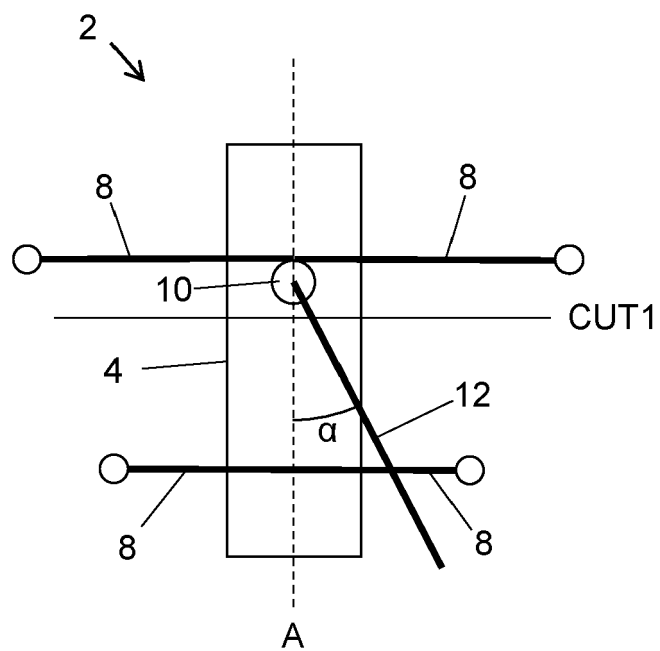


FIG. 5

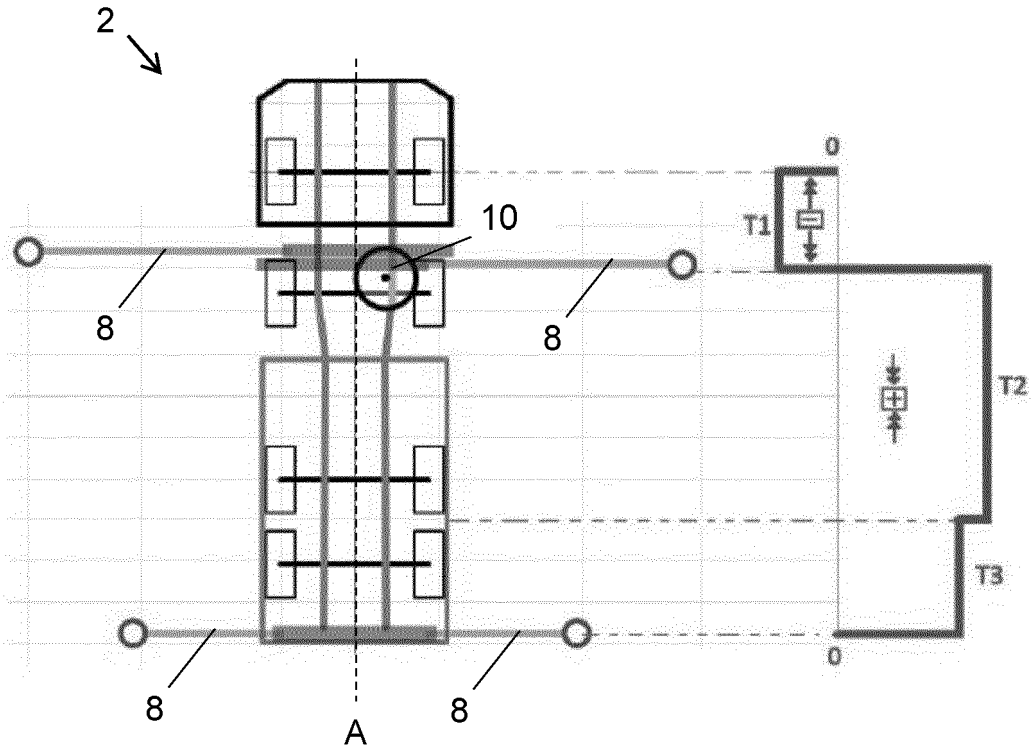


FIG. 6

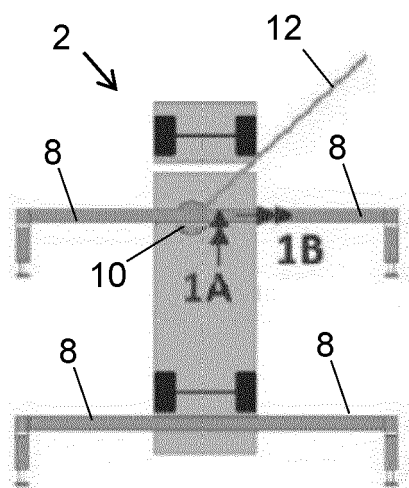


FIG. 7A

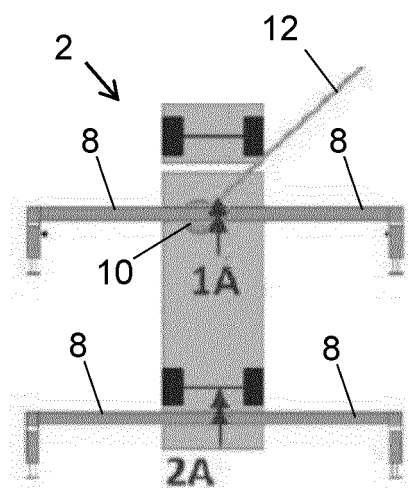


FIG. 7B

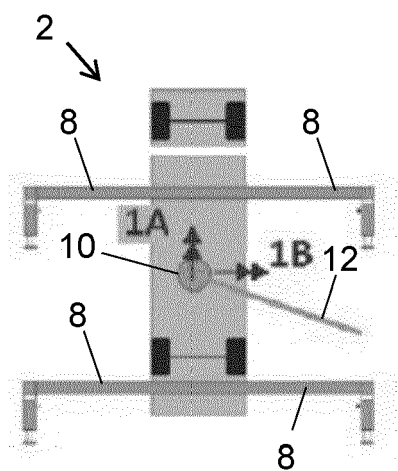


FIG. 7C

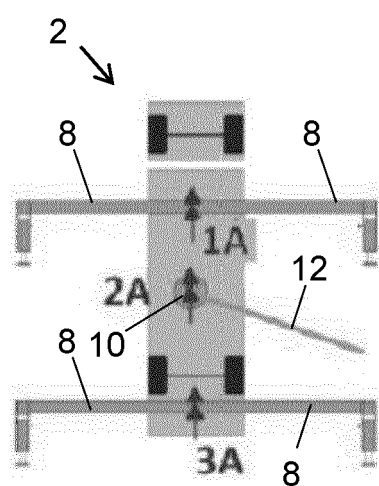


FIG. 7D

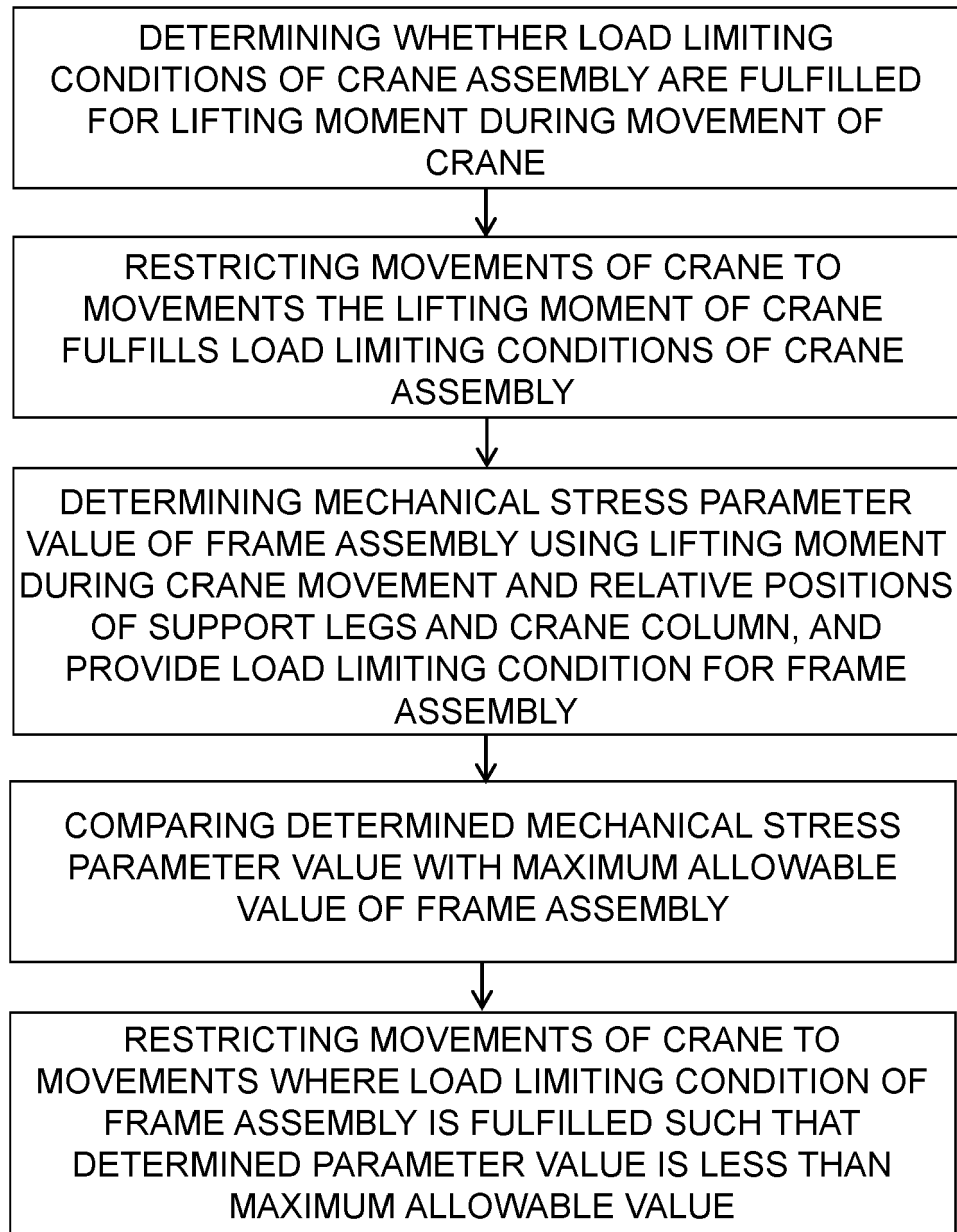


FIG. 8

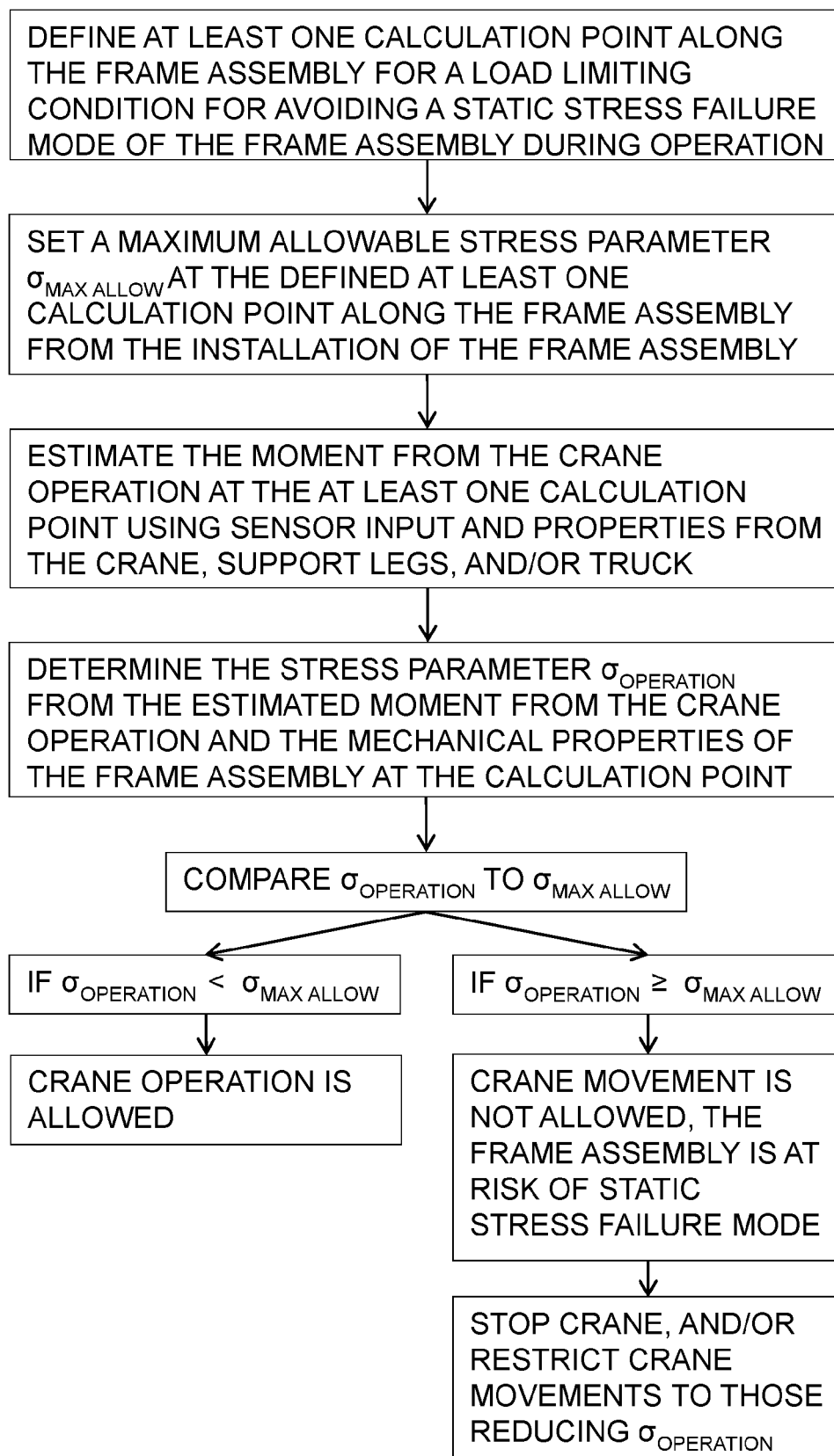


FIG. 9



EUROPEAN SEARCH REPORT

Application Number

EP 22 15 9457

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	JP H04 256691 A (KOBE STEEL LTD) 11 September 1992 (1992-09-11) * paragraphs [0021], [0024], [0037], [0051] - [0059], [0075] * -----	1-14	INV. B66C23/90
A	US 6 138 845 A (KASPAR ERNST [DE]) 31 October 2000 (2000-10-31) * the whole document * -----	1-14	
A	US 6 202 013 B1 (ANDERSON THOMAS M [US] ET AL) 13 March 2001 (2001-03-13) * the whole document * -----	1-14	
			TECHNICAL FIELDS SEARCHED (IPC)
			B66C
The present search report has been drawn up for all claims			

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Place of search	Date of completion of the search	Examiner
The Hague	12 August 2022	Lenoir, Xavier
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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ON EUROPEAN PATENT APPLICATION NO.**

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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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12-08-2022

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP H04256691 A	11-09-1992	JP H04256691 A	11-09-1992
		JP H07106876 B2	15-11-1995
US 6138845 A	31-10-2000	DE 29613415 U1	19-09-1996
		JP 3126987 B2	22-01-2001
		JP 2000502650 A	07-03-2000
		US 6138845 A	31-10-2000
		WO 9805581 A2	12-02-1998
US 6202013 B1	13-03-2001	NONE	

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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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Patent documents cited in the description

- US 6170681 B1 [0007]
- US 4276985 A [0008]
- US 20070012641 A1 [0009]
- JP 2003252590 A [0010]