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(54) LORRY AND METHOD FOR REGULATING THE MAXIMUM ALLOWED LIFTING MOMENT OF A HYDRAULIC LORRY CRANE

(57) The invention relates to a lorry with at least two pairs of stabilizer legs (10a, 10b, 11a, 11b). A hydraulic crane (20) is carried by the chassis (5) of the lorry and comprises a rotatable column (22). An electronic control device is configured to establish a lifting moment limit value while taking into account the stability of the lorry against tipping, wherein this limit value represents the maximum allowed value for the lifting moment of the crane. The electronic control device adjusts said limit value in dependence on the slewing angle (θ) of the column such that the twisting of the chassis induced by the weight of the crane and the load carried by the crane is limited so that the consequential lifting of a stabilizer leg from the ground is prevented from exceeding a predetermined level. The invention also relates to a method for regulating the maximum allowed lifting moment of a hydraulic crane.

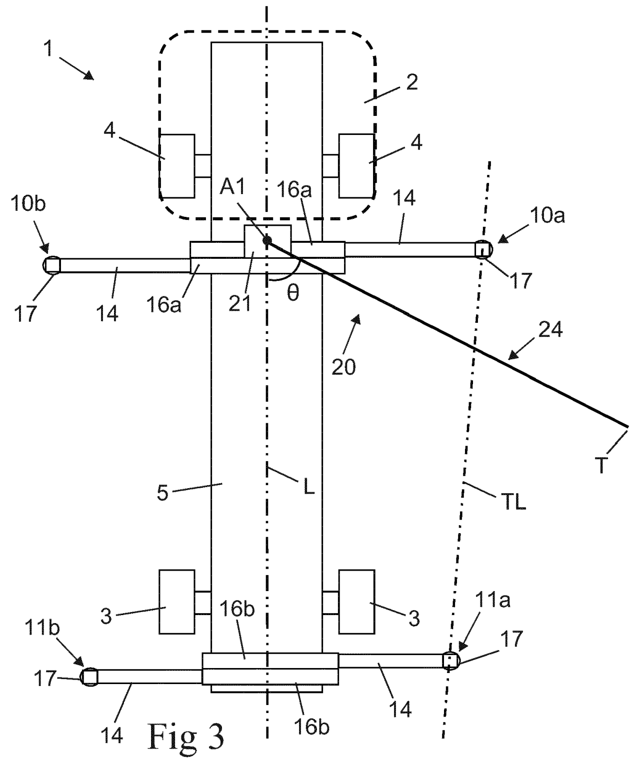

Fig 3

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Description

FIELD OF THE INVENTION AND PRIOR ART

[0001] The present invention relates to a lorry according to the preamble of claim 1 and a method for regulating the maximum allowed lifting moment of a hydraulic lorry crane.

[0002] In order to avoid overloading of a hydraulic crane, it is known to establish a, with respect to the strength of the crane, maximum allowed value for the lifting moment of the crane. The expression "base value" is in the following used as a denomination for this maximum allowed value for the lifting moment of the crane established based on the strength properties of the crane. This base value may be a fixed value which takes into account the position of the crane boom system which, with respect to strength, is the most critical one among the allowed positions for the crane boom system of the crane, or a variable value established repeatedly in dependence on the swing-out angle of the inner boom of the crane and possibly further variables defining the prevailing position of the crane boom system of the crane. The value of the maximum allowed lifting moment is normally converted into a corresponding value for the maximum allowed working pressure for the lifting cylinder of the crane, and by limiting this working pressure it is secured that the lifting moment of the crane will not exceed the maximum allowed lifting moment.

[0003] For a hydraulic lorry crane, i.e. a hydraulic crane mounted on a lorry, the value of the maximum allowed lifting moment also has to be adapted in dependence on the stability of the lorry, to thereby avoid a tipping of the lorry due to inappropriate manoeuvring of the crane. To prevent the lorry from tipping, the tipping moment presently exerted on the lorry by the crane and by the load carried by the crane has to be lower than the stabilizing moment given by the weight of the lorry without cargo in combination with the weight of the possible load located on the lorry. The magnitude of the tipping moment and the stabilizing moment depends i.a. on the position of the tipping line over which the crane boom system of the crane presently extends. The position of the tipping line can be established based on information about the slewing angle of the column of the crane and information about the horizontal extension length of the stabilizer legs of the lorry. When the position of the tipping line of the lorry is known, the perpendicular distance between the tipping line and the centre of gravity of the lorry without cargo can be calculated, which in its turn makes it possible to calculate the stabilizing moment given by the weight of the lorry without cargo. When the position of the tipping line, the slewing angle of the column of the crane and the lifting radius of the crane are known, the perpendicular distance between the tipping line and the load suspension point of the crane can be calculated, which in its turn makes it possible to estimate the tipping moment exerted by the crane when the lifting moment of the crane corresponds to the above-mentioned base value for the maximum allowed lifting moment.

[0004] According to a known principle for stability monitoring of a lorry crane, the tipping moment M_O exerted by the crane when the lifting moment of the crane corresponds to the above-mentioned base value $M_{C,base}$ for the maximum allowed lifting moment and the stabilizing moment M_S given by the weight of the lorry without cargo are calculated in the manner described above. Thereafter, it is checked whether a predetermined stability condition is fulfilled with these tipping and stabilizing moments, namely whether the ratio between the stabilizing moment M_S and the tipping moment M_O is equal to or larger than the value of a given stability constant k. If the stability condition is fulfilled, i.e. if $M_S/M_O \geq k$, said base value $M_{C,base}$ is used as an upper limit for the allowed lifting moment of the crane. If the stability condition is not fulfilled, i.e. $M_S/M_O < k$, a reduction factor κ_s is established, and a reduced value $M_{C,red}$ for the maximum allowed lifting moment of the crane is established as the product of the base value $M_{C,base}$ and the reduction factor κ_s, i.e. $M_{C,red} = M_{C,base} \cdot \kappa_s$. The reduction factor κ_s is calculated as the quotient between the stabilizing moment M_S and the product of the stability constant k and the tipping moment M_O, i.e. $\kappa_s = M_S/(k \cdot M_O)$. The reduced value $M_{C,red}$ is then used as an upper limit for the maximum allowed lifting moment of the crane.

[0005] It is also previously known, when monitoring the stability of a lorry crane, to take into account the stabilizing moment given by the load presently located on the lorry. This may for instance be done in the manner described in EP 2 298 689 B1. When the stabilizing moment given by the load presently located on the lorry is taken into account, it will in some lifting situations be possible to establish a value for the maximum allowed lifting moment of the crane that is higher than the value that would have been established without taking this stabilizing moment into account.

[0006] When a hydraulic loader crane of bigger type is installed on a lorry, a subframe is normally arranged between the ordinary chassis frame of the lorry and the crane base. This subframe is fixed to the ordinary chassis frame in order to increase the strength thereof. In this description and the subsequent claims, the unit formed by the ordinary chassis frame and the associated subframe is referred to as the "chassis" of the lorry. However, in case of a lorry provided with a hydraulic crane mounted directly onto the ordinary chassis frame of the lorry without any intermediate subframe, the expression "chassis" refers to the ordinary chassis frame of the lorry.

[0007] On a lorry having a hydraulic loader crane mounted on its chassis, stabilizer legs that are connected to the chassis and moveable outwards from the chassis to supporting positions beyond the opposite longitudinal sides of the lorry are normally used in order to increase the stability against tipping of the lorry. A lorry equipped with a hydraulic loader crane of bigger type is normally provided with at least two pairs of such stabilizer legs, including a pair of main stabilizer legs connected to the chassis of the lorry in the vicinity of the crane base and a pair of additional stabilizer legs arranged at a distance from the main stabilizer legs as seen in the longitudinal direction of the chassis. When the crane base and the main stabilizer legs are arranged closely behind the driver's cab, said additional stabilizer legs are arranged at the rear end of the chassis. When the crane base and the main stabilizer legs are arranged at the rear end of the chassis, said additional stabilizer legs are arranged closely behind the driver's cab.

[0008] When a lorry crane is operated and the stabilizer legs are in supporting contact with the ground, the chassis of the lorry is subjected to torque caused by the weight of the crane and the weight of the load carried by the crane. This torque may cause twisting of the chassis, which in its turn may result in a lifting of the main stabilizer leg that is positioned on the opposite side of the longitudinal axis of the chassis as compared to the tip of the crane. The torque on the chassis is zero or at least close to zero when the crane booms of the crane are positioned in or close to the vertical plane that extends along the longitudinal axis of the chassis, i.e. when the slewing angle is zero. For a given lifting radius of the crane, the torque on the chassis varies in dependence on the slewing angle of the column in relation to the chassis. At slewing angles where the stability of the lorry is good and the maximum allowed lifting moment therefore has a high value, and where, at the same time, the weight of the crane and the weight of the load carried by the crane cause high torque on the chassis, the main stabilizer leg that is positioned on the opposite side of the longitudinal axis of the chassis as compared to the tip of the crane may be lifted several decimetres from the ground as a consequence of the resulting twisting of the chassis when the prevailing lifting moment of the crane is close to the prevailing value of the maximum allowed lifting moment established based on the strength of the crane and the stability of the lorry. Even though such a high lifting of the stabilizer leg in question does not represent any security risk with respect to the strength of the crane and does not jeopardize the stability of the lorry against tipping, it may nevertheless look unpleasant and give a feeling of insecurity for the operator of the crane and for other people in the vicinity of the lorry. A known manner of avoiding an excessive lifting of a stabilizer leg from the ground is to dimension the subframe with a sufficient torsional stiffness in connection with the installation of the crane on the lorry.

OBJECT OF THE INVENTION

[0009] The object of the present invention is to provide a new and favourable manner of controlling the maximum lifting of a stabilizer leg from the ground due to the twisting of the chassis of a lorry caused by the weight of a hydraulic lorry crane and the weight of the load carried by the crane.

SUMMARY OF THE INVENTION

[0010] According to the present invention, said object is achieved by means of a lorry having the features defined in claim 1 and a method having the features defined in claim 4.

[0011] According to the present invention, the lifting moment limit value, which is established in a conventional manner while taking into account the stability of the lorry against tipping and which represents the maximum allowed value for the lifting moment of the crane, is adjusted in dependence on the slewing angle of the column of the crane in relation to the chassis such that the twisting of the chassis induced by the weight of the crane and the load carried by the crane is limited so that the consequential lifting of a stabilizer leg from the ground is prevented from exceeding a predetermined level. Thus, an excessive lifting of a stabilizer leg from the ground is prevented by adjusting the lifting moment limit value in dependence on the slewing angle of the column of the crane in relation to the chassis, wherein a reduction of the lifting moment limit value is introduced at slewing angles where a lifting moment corresponding to the lifting moment limit value established in a conventional manner would result in a lifting of a stabilizer leg above the predetermined level.

[0012] Further advantageous features of the lorry according to the present invention will appear from the description following below and the dependent claims.

[0013] The invention also relates to a method having the features defined in claim 4.

[0014] Further advantageous features of the method according to the present invention will appear from the description following below and the dependent claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] The invention will in the following be more closely described by means of embodiment examples, with reference to the appended drawings. It is shown in:

- Fig 1 a schematic rear view of a lorry provided with stabilizer legs and a hydraulic crane;
- Fig 2 a schematic perspective view of a manoeuvring unit with a number of manoeuvring members for controlling different crane functions;
- Fig 3 a schematic planar view from above of the lorry, the stabilizer legs and the crane according to Fig 1;
- Fig 4 a diagram illustrating the relationship between the slewing angle of the crane and a reduction factor used in the execution of a method according to an embodiment of the invention; and
- Fig 5 a schematic illustration of an embodiment of a

crane included in a lorry according to the present invention.

DETAILED DESCRIPTION OF EMBODIMENTS OF THE INVENTION

[0016] A lorry 1 according to an embodiment of the present invention is very schematically illustrated in Figs 1 and 3. The lorry 1 is provided with load-bearing vehicle wheels 3, 4 and a chassis 5 supported by the vehicle wheels. In the illustrated example, the lorry is provided with two rear wheels 3 and two front wheels 4, but the lorry 1 could also be provided with a larger number of load-bearing vehicle wheels than here illustrated. A driver's cab 2 and a hydraulic crane 20 are mounted on and carried by the chassis 5. The driver's cab 2 is schematically illustrated by broken lines in Fig 3.

[0017] In the illustrated embodiment, the chassis 5 comprises the ordinary chassis frame 5a of the lorry 1 and a subframe 5b fixed to this chassis frame 5a, wherein the crane 20 is mounted to the subframe 5b.

[0018] The lorry 1 comprises several stabilizer legs for supporting the lorry against the ground 6, wherein these stabilizer legs include a first pair of stabilizer legs 10a, 10b (see Fig 3) and a second pair of stabilizer legs 11a, 11b connected to the chassis 5 at two different positions between the driver's cab 2 and the rear end of the chassis. Thus, the first pair of stabilizer legs 10a, 10b and the second pair of stabilizer legs 11a, 11b are spaced apart in the longitudinal direction of the chassis 5. Each one of these pairs comprises one stabilizer leg 10a, 11a moveable into supporting contact with the ground on a first side of the longitudinal axis L of the chassis 5 and another stabilizer leg 10b, 11b moveable into supporting contact with the ground on an opposite second side of the longitudinal axis L of the chassis 5. The lorry could alternatively be provided with a larger number of stabilizer legs than here illustrated. The stabilizer legs 10a, 10b, 11a, 11b are connected to the chassis 5 of the vehicle 2.

[0019] Each stabilizer leg 10a, 10b, 11a, 11b has an actuating member 12, by means of which the stabilizer leg is manoeuvrable between a raised inactive position, in which the stabilizer leg is out of contact with the ground 6, and an active supporting position (see Fig 1), in which the stabilizer leg is lowered into supporting contact with the ground. In the illustrated embodiment, the actuating member 12 of each stabilizer leg has the form of a hydraulic cylinder with a cylinder part 13a, which forms an upper part of the stabilizer leg, and a piston rod 13b, which forms a lower part of the stabilizer leg. The piston rod 13b is at its upper end fixed to a piston (not shown), which is received in the cylinder part 13a and displaceable in relation to it. A foot plate 17 may be fixed to the lower end of the piston rod 13b.

[0020] In the illustrated embodiment, each stabilizer leg 10a, 10b, 11a, 11b is mounted to an extension arm 14 at an outer end thereof. The extension arm 14 is telescopically extensible by means of an actuating member 15, preferably in the form of a hydraulic cylinder, in order to allow an adjustment of the horizontal extension length thereof and thereby an adjustment of the horizontal extension length of the associated stabilizer leg. As an alternative, each extension arm 14 could be manually extensible. By adjustment of the extension length of the extension arm 14, the stabilizer leg 10a, 10b, 11a, 11b is moveable in horizontal direction in relation to the chassis 5 of the lorry 1 from a retracted position close to the chassis 5 to an advanced position at a distance from the chassis.

[0021] Each extension arm 14 is slidably mounted to a support beam 16a, 16b, which in its turn is connected to the chassis 5 of the lorry 1. In the embodiment illustrated in Fig 3, the support beams 16a of the first pair of stabilizer legs 10a, 10b are rigidly mounted to a crane base 21 of the hydraulic crane 20, wherein these support beams 16a are connected to the chassis 5 via the crane base 21, and the support beams 16b of the second pair of stabilizer legs 11a, 11b are rigidly mounted directly to the chassis 5 at a rear end of the lorry 1. In the following, the stabilizer legs 10a, 10b that are connected to the crane base 21 are referred to as the main stabilizer legs.

[0022] In the illustrated embodiment, the hydraulic crane 20 comprises:

- a crane base 21, which is fixed to and carried by the chassis 5 of the lorry 1;
- a column 22, which is rotatably mounted to the crane base 21 so as to be rotatable in relation to the crane base about an essentially vertical axis of rotation A1 by means of an actuating member 23, for instance in the form of a hydraulic cylinder; and
- a crane boom system 24 carried by the column 22.

[0023] The crane boom system 24 comprises a first liftable and lowerable crane boom 25, the so-called inner boom, which is articulately connected to the column 22 in such a manner that it is pivotable in relation to the column about an essentially horizontal axis of rotation A2, and an actuating member in the form of a hydraulic cylinder 26, here denominated lifting cylinder, for lifting and lowering the inner boom 25 in relation to the column 22.

[0024] In the illustrated embodiment, the crane boom system 24 also comprises a liftable and lowerable second crane boom 27, a so-called outer boom, which is articulately connected to the inner boom 25 in such a manner that it is pivotable in relation to the inner boom about an essentially horizontal axis of rotation A3, and an actuating member in the form of a hydraulic cylinder 28 for lifting and lowering of the outer boom 27 in relation to the inner boom 25. The outer boom 27 is telescopically extensible to enable an adjustment of the extension length thereof. The outer boom 27 comprises a base section 27a, through which the outer boom 27 is articulately connected to the inner boom 25, and a telescopic crane boom section 27b which is carried by the base section 27a and displaceable in the longitudinal direction of the base section by means of an actuating member in the form of a hydraulic cylinder 29 for adjustment of the extension length of the outer boom 27. The outer boom 27 could as an alternative be provided with two or more telescopic crane boom sections.

[0025] In the illustrated embodiment, the crane boom system 24 of the crane 20 is formed by the inner boom 25 and the outer boom 27 and the associated hydraulic cylinders 26, 28, 29. However, the crane boom system 24 of the crane 20 may as an alternative include only one liftable and lowerable crane boom or more than two liftable and lowerable crane booms articulately connected to each other.

[0026] In the illustrated example, a load handling tool 17 provided with a rotator 18 and a lifting hook 19 is articulately connected to a boom tip at the outer end of the outer boom 27. As an alternative, any other suitable type of load handling tool may be connected to the boom tip. In order to extend the reach of the crane 20, i.e. the possible range of the lifting operations, an additional crane boom, a so-called jib, may be temporarily and detachably mounted to the outer end of the outer boom 27.

[0027] The slewing angle θ of the column 22 in relation to the chassis 5 in the horizontal plane is established by means of a sensor 41 (schematically illustrated in Fig 5), which continuously senses the slewing position of the column. This slewing angle θ defines the horizontal orientation of the crane boom system 24 in relation to the chassis 5 and the stabilizer legs 10a, 10b, 11a, 11b.

[0028] The lorry 1 comprises a manoeuvring unit 30, for instance in the form of a portable manoeuvring unit of the type illustrated in Fig 2, with one or more manoeuvring members 31 configured to be manoeuvrable by a crane operator in order to control the movements of the crane booms 25, 27 of the crane boom system 24. Control signals are transmitted via cable or a wireless connection from the manoeuvring unit 30 to an electronic control device 40 (schematically illustrated in Fig 5), which in its turn is configured to control the actuating members 23, 26, 28, 29 of the crane 20 in a conventional manner, and thereby the crane boom movements, on the basis of control signals from the manoeuvring unit 30 related to the manoeuvring of the manoeuvring members 31. The electronic control device 40 comprises a microprocessor or the similar for processing the control signals from the manoeuvring unit 30.

[0029] The control system for controlling the hydraulic cylinders 23, 26, 28, 29 of the crane 20 comprises a pump 50 (see Fig 5) which pumps hydraulic fluid from a reservoir 51 to a directional-control-valve block 52. The directional-control-valve block 52 comprises a directional-control-valve section 53 for each of the hydraulic cylinders 23, 26, 28, 29 of the crane 20, to which hydraulic cylinders hydraulic fluid is supplied in a conventional manner in dependence on the setting position of the slide member in the respective directional-control-valve section 53. The electronic control device 40 controls the setting position of the slide members in the valve sections 53 of the directional-control-valve block 52 in dependence on control signals from the manoeuvring unit 30 related to the manoeuvring of the manoeuvring members 31. Each individual directional-control-valve section 53 controls the magnitude and the direction of the flow of hydraulic fluid to a specific hydraulic cylinder 23, 26, 28, 29 and thereby controls a specific crane function. For the sake of clarity, only the directional-control-valve section 53 for the lifting cylinder 26 is illustrated in Fig 5.

[0030] The directional-control-valve block 52 further comprises a shunt valve 56, which pumps excessive hydraulic fluid back to the reservoir 51, and an electrically controlled dump valve 57, which can be made to return the entire hydraulic flow from the pump 50 directly back to the reservoir 51.

[0031] In the illustrated example, the directional-control-valve block 52 is of load-sensing and pressure-compensating type, which implies that the magnitude of the hydraulic flow supplied to a hydraulic cylinder is always proportional to the position of the slide member in the corresponding directional-control-valve section 53. The directional-control-valve section 53 comprises a pressure limiter 58, a pressure compensator 59 and a directional-control-valve 60. Directional-control-valve blocks and directional-control-valve sections of this type are known and available on the market. Also other types of valve devices then the one here described may of course be used in a crane included in a lorry according to the present invention.

[0032] A load holding valve 61 is arranged between each hydraulic cylinder 23, 26, 28, 29 and the associated directional-control-valve section 53, which load holding valve makes sure that the load will remain hanging when the hydraulic system runs out of pressure when the dump valve 57 is made to return the entire hydraulic flow from the pump 50 directly back to the reservoir 51.

[0033] The electronic control device 40 is configured to check whether one or more predetermined stability conditions for the lorry are fulfilled with a lifting moment of the crane 20 corresponding to a, with respect to the strength of the crane, maximum allowed value $M_{C,base}$, here denominated base value, for the lifting moment of the crane. This base value $M_{C,base}$ may be a given fixed value which takes into account the position of the crane boom system 24 which, with respect to strength, is the most critical one among the allowed positions for the crane boom system of the crane, or a variable value established by the electronic control device 40 in dependence on the swing-out angle of the inner boom 25 in the vertical plane and possibly further variables defining the prevailing position of the crane boom system 24

[0034] The electronic control device 40 is configured to establish a reduced value $M_{C,red}$ for the maximum allowed lifting moment of the crane in a situation when it is established by the electronic control device 40 that the stability condition is not fulfilled. It is well known to a person skilled in the art how such a reduced value $M_{C,red}$

for the maximum allowed lifting moment of the crane 20 may be established while taking into account the stability of the lorry 1 against tipping from the stabilizer legs 10a, 10b, 11a, 11b that are in supporting contact with the ground. This well known procedure will not be described here in closer detail. The electronic control device 40 may for instance be configured to establish said reduced value $M_{C,red}$ for the maximum allowed lifting moment of the crane 20 in the manner described in closer detail in EP 2 298 689 B1, in which case the electronic control device 40 is configured to establish this reduced value $M_{C,red}$ while taking into account the horizontal extension length of each stabilizer leg 10a, 10b, 11a, 11b that is in an active support position, the slewing angle θ of the column 22 in relation to the chassis 5, and the force exerted by the actuating member 12 of each stabilizer leg that is in an active support position and is not included in the prevailing tipping line TL of the lorry 1.

[0035] In the following, the above-mentioned reduced value $M_{C,red}$ for the maximum allowed lifting moment of the crane 20 will be referred to as "stability adapted lifting moment limit value".

[0036] As previously discussed, the chassis 5 of the lorry is subjected to torque caused by the weight of the crane 20 and the weight of the load carried by the crane. This torque may cause twisting of the chassis 5, which in its turn may result in a lifting from the ground of the main stabilizer leg that is positioned on the opposite side of the longitudinal axis L of the chassis 5 as compared to the tip T of the crane. Thus, in the example illustrated in Fig 3 with the crane boom system 24 crossing a tipping line TL that extends between the stabilizer legs 10a, 11a on the right side of the longitudinal axis L of the chassis 5, the main stabilizer leg 10b on the left side of the longitudinal axis L may be lifted from the ground due to the torque on the chassis 5.

[0037] According to the present invention, the electronic control device 40 is configured to take into account the above-mentioned torque when establishing the prevailing value of the maximum allowed lifting moment of the crane 20, i.e. when establishing the lifting moment limit value M_{max} to be used in the supervision of the movements of the crane boom system 24. The electronic control device 40 is configured to take this torque into account by adjusting the lifting moment limit value M_{max} in dependence on the slewing angle θ of the column 22 in relation to the chassis 5 such that the twisting of the chassis 5 induced by the weight of the crane 20 and the load carried by the crane is limited so that the consequential lifting of one of the main stabilizer legs 10a, 10b from the ground is prevented from exceeding a predetermined level. This predetermined level may for instance be set to correspond to a maximum vertical distance between the ground and the foot plate 17 of the stabilizer leg 10a, 10b in the order of 0-250 mm.

[0038] The electronic control device 40 may for instance be configured to take said torque into account by establishing a torsion adapted lifting moment limit value $M_{C,t}$ as the product of the above-mentioned base value $M_{C,base}$ and a reduction factor κ_t, wherein the reduction factor κ_t has a maximum value of 1 and is established by the electronic control device 40 in dependence on the slewing angle θ of the column 22 in relation to the chassis 5. The prevailing value of reduction factor κ_t is established by the electronic control device 40 by means of a calculation model or look-up table with the slewing angle θ as input value. Such a look-up table or calculation model may be stored in a memory of the electronic control device 40 or on a data storage medium connected to the electronic control device.

[0039] A suitable relationship between the reduction factor κ_t and the slewing angle θ depends i.a. on the torsional resistance of the chassis 5, the distance between the stabilizer legs 10a, 10b included in the first pair of stabilizer legs and the distance from the support beams 16a of the first pair of stabilizer legs 10a, 10b to the support beams 16b of the second pair of stabilizer legs 11a, 11b. Such a relationship may for instance be established empirically by practical tests in connection with the installation of the crane 20 on the lorry 1, for instance by observing at which slewing angles θ a main stabilizer leg 10a, 10b is lifted from the ground to a height above a predetermined level when a lifting moment corresponding to the above-mentioned base value $M_{C,base}$ is applied and then reducing the applied lifting moment at each such slewing angle until the lifting height of the stabilizer leg in question has been lowered to the predetermined level, wherein the reduction factor κ_t at the slewing angle in question is given as the quotient between this reduced value of the lifting moment and the base value $M_{C,base}$. At slewing angles where an application of a lifting moment corresponding to the base value $M_{C,base}$ does not cause any stabilizer leg to be lifted from the ground to a height above the predetermined level, the value of the reduction factor κ_t is set to 1. The empirically established relationship between the reduction factor κ_t and the slewing angle θ may then be expressed as a look-up table with the slewing angle θ as input value or as a mathematical formula with the slewing angle θ as variable.

[0040] As a further alternative, a suitable relationship between the reduction factor κ_t and the slewing angle θ may be established by means of a calculation model that is based on a theoretical formula that approximately reflects the true relationship between the applied lifting moment and the lifting height of a main stabilizer leg 10a, 10b at different slewing angles.

[0041] A possible diagram for the value of the reduction factor $\kappa_t(\theta)$ as a function of the slewing angle θ is illustrated in Fig 4. In this diagram the slewing angle θ is defined in the manner illustrated in Fig 3, which implies that the slewing angle θ in this case is zero when the crane boom system 24 is oriented rearwards along the longitudinal axis L of the chassis 5, wherein the slewing angle θ is defined as positive when the tip T of the crane is in a position on a first side of the longitudinal axis L of the chassis 5 and as negative when the tip T of the crane is in a position on an opposite second side of the longitudinal axis L of the chassis 5.

[0042] As an alternative to calculating the torsion adapted lifting moment limit value $M_{C,t}$ in the above-mentioned manner as the product of the base value $M_{C,base}$ and a reduction factor κ_t, it would also be possible to use a look-up table or calculation model which directly expresses the torsion adapted lifting moment limit value $M_{C,t}$ as a function of the slewing angle θ.

[0043] A stability adapted lifting moment limit value value $M_{C,red}$ is only established by the electronic control device 40 in a situation when it is established by the electronic control device 40 that the given stability condition is not fulfilled, whereas a torsion adapted lifting moment limit value $M_{C,t}$ is established by the electronic control device 40 in any situation during the operation of the crane 20. In a situation when it is established by the electronic control device 40 that the stability condition is fulfilled, the electronic control device 40 will set the lifting moment limit value M_{max} to correspond to the torsion adapted lifting moment limit value $M_{C,t}$ at the prevailing slewing angle θ. In a situation when it is established by the electronic control device 40 that the stability condition is not fulfilled, the electronic control device 40 will set the lifting moment limit value M_{max} to correspond to the lowest of the stability adapted lifting moment limit value value $M_{C,red}$ and the torsion adapted lifting moment limit value $M_{C,t}$ at the prevailing slewing angle θ.

[0044] The electronic control device 40 is with advantage, in a conventional manner, configured to convert the prevailing lifting moment limit value M_{max} into a corresponding value for the maximum allowed working pressure for the lifting cylinder 26. In the embodiment illustrated in Fig 5, the crane 1 comprises a pressure sensor 62 which is arranged to measure the hydraulic pressure on the piston side of the lifting cylinder 26. The electronic control device 40 is connected to the pressure sensor 62 in order to receive measuring signals from this sensor related to said hydraulic pressure. The electronic control device 40 continuously reads the output signals from the pressure sensor 62 and compares the output signal from the pressure sensor with the established value of the maximum allowed working pressure for the lifting cylinder 26. If the pressure sensed by the pressure sensor 62 exceeds the established maximum allowed working pressure for the lifting cylinder 26, the electronic control device 40 delivers a signal to the dump valve 57, which dumps the hydraulic flow directly to the reservoir 51, which results in that the hydraulic system runs out of pressure and that the presently executed crane boom movements are stopped.

[0045] In the example described above, the electronic control device 40 is configured to let the maximum allowed working pressure for the lifting cylinder 26 represent the maximum allowed hydraulic pressure on the piston side of the lifting cylinder. However, the electronic control device 40 could alternatively be configured to let the maximum allowed working pressure for the lifting cylinder 26 represent the maximum allowed differential pressure in the lifting cylinder. This differential pressure is defined as the hydraulic pressure on the piston side of the lifting cylinder minus the hydraulic pressure on its piston rod side divided by the cylinder ratio. In the last-mentioned case, the electronic control device 40 is also arranged to receive measuring signals from a pressure sensor which measures the hydraulic pressure on the piston rod side of the lifting cylinder 26 so as to thereby be able to establish the prevailing differential pressure of the lifting cylinder and compare this differential pressure with the established value of the maximum allowed working pressure for the lifting cylinder. The expression "working pressure" as used in this description consequently refers either to the hydraulic pressure on the piston side of a hydraulic cylinder or the differential pressure in a hydraulic cylinder.

[0046] The electronic control device 40 may be implemented by one single electronic control unit, as illustrated in Fig 5. However, the electronic control device 40 could as an alternative be implemented by two or more mutually co-operating electronic control units.

[0047] The invention is of course not in any way limited to the embodiments described above. On the contrary, several possibilities to modifications thereof should be apparent to a person skilled in the art without thereby deviating from the basic idea of the invention as defined in the appended claims. The control system of the crane may for instance have another design than the control system which is illustrated in Fig 5 and described above.

Claims

1. A lorry comprising:

- a chassis (5);
- a first pair of stabilizer legs (10a, 10b) and a second pair of stabilizer legs (11a, 11b) connected to the chassis (5) and spaced apart in the longitudinal direction of the chassis, wherein each one of these pairs comprises one stabilizer leg (10a, 11a) moveable into supporting contact with the ground on a first side of the longitudinal axis (L) of the chassis (5) and another stabilizer leg (10b, 11b) moveable into supporting contact with the ground on an opposite second side of the longitudinal axis (L) of the chassis (5);
- a hydraulic crane (20), which is carried by the chassis (5) and comprises:
    - a crane base (21) fixed to the chassis (5),
    - a column (22), which is rotatably mounted to the crane base (21) so as to be rotatable in relation to the crane base (21) about an essentially vertical axis of rotation (A1), and
    - a crane boom system (24) carried by the column (22); and

- an electronic control device (40), which is configured to establish a lifting moment limit value (M_{max}) while taking into account the stability of the lorry (1) against tipping from the stabilizer legs (10a, 10b, 11a, 11b) that are in supporting contact with the ground, wherein the lifting moment limit value (M_{max}) represents the maximum allowed value for the lifting moment of the crane (20),

characterized in that the electronic control device (40) is configured to adjust the lifting moment limit value (M_{max}) in dependence on the slewing angle (θ) of the column (22) in relation to the chassis (5) such that the twisting of the chassis (5) induced by the weight of the crane (20) and the load carried by the crane is limited so that the consequential lifting of a stabilizer leg (10a, 10b) from the ground is prevented from exceeding a predetermined level.

2. A lorry according to claim 1, **characterized in:**

- **that** the electronic control device (40) is configured to check whether one or more predetermined stability conditions for the lorry (1) are fulfilled at the prevailing slewing angle (θ) with a lifting moment of the crane (20) corresponding to a, with respect to the strength of the crane, maximum allowed value ($M_{C,base}$), here denominated base value, for the lifting moment of the crane, wherein the electronic control device (40) is configured to establish a reduced value ($M_{C,red}$) for the maximum allowed lifting moment of the crane if said one or more stability conditions are not fulfilled;
- **that** the electronic control device (40) is configured to establish, based on the prevailing value of the slewing angle (θ), an adjusted lifting moment limit value ($M_{C,t}$) that prevents a possible lifting of a stabilizer leg (10a, 10b) from the ground due to said twisting of the chassis (5) from exceeding the predetermined level; and
- **that** the electronic control device (40) is configured to set the lifting moment limit value (M_{max}) to correspond to said adjusted lifting moment limit value ($M_{C,t}$) if said one or more stability conditions are fulfilled and to correspond to the lowest of said reduced value ($M_{C,red}$) and said adjusted lifting moment limit value ($M_{C,t}$) if said one or more stability conditions are not fulfilled.

3. A lorry according to claim 2, **characterized in that** the electronic control device (40) is configured to establish said adjusted lifting moment limit value ($M_{C,t}$) as the product of said base value ($M_{C,base}$) and a reduction factor (κ_t), which is established by the electronic control device (40) by means of a calculation model or look-up table with the slewing angle (θ) as input value.

4. A method for regulating the maximum allowed lifting moment of a hydraulic crane (20) carried by a chassis (5) of a lorry (1), where the lorry comprises a first pair of stabilizer legs (10a, 10b) and a second pair of stabilizer legs (11a, 11b) connected to the chassis (5) and spaced apart in the longitudinal direction of the chassis, each one of these pairs comprising one stabilizer leg (10a, 11a) moveable into supporting contact with the ground on a first side of the longitudinal axis (L) of the chassis (5) and another stabilizer leg (10b, 11b) moveable into supporting contact with the ground on an opposite second side of the longitudinal axis (L) of the chassis (5), and where the crane (20) comprises:

• a crane base (21) fixed to the chassis (5),
• a column (22), which is rotatably mounted to the crane base (21) so as to be rotatable in relation to the crane base (21) about an essentially vertical axis of rotation (A1), and
• a crane boom system (24) carried by the column (22),

the method comprising the steps of:

- establishing, by means of an electronic control device (40), a lifting moment limit value (M_{max}) while taking into account the stability of the lorry (1) against tipping from the stabilizer legs (10a, 10b, 11a, 11b) that are in supporting contact with the ground, wherein the lifting moment limit value (M_{max}) represents the maximum allowed value for the lifting moment of the crane (20); and
- adjusting the lifting moment limit value (M_{max}) by means of the electronic control device (40) in dependence on the slewing angle (θ) of the column (22) in relation to the chassis (5) such that the twisting of the chassis (5) induced by the weight of the crane (20) and the load carried by the crane is limited so that the consequential lifting of a stabilizer leg (10a, 10b) from the ground is prevented from exceeding a predetermined level.

5. A method according to claim 4, **characterized in:**

- **that** the electronic control device (40) checks whether one or more predetermined stability conditions for the lorry (1) are fulfilled at the prevailing slewing angle (θ) with a lifting moment of the crane corresponding to a, with respect to the strength of the crane (20), maximum allowed value ($M_{C,base}$), here denominated base value, for the lifting moment of the crane, wherein a reduced value ($M_{C,red}$) for the maximum allowed lifting moment of the crane (20) is established by means of the electronic control device (40) if said one or more stability conditions are not fulfilled;

- **that** an adjusted lifting moment limit value ($M_{C,t}$) that prevents a possible lifting of a stabilizer leg (10a, 10b) from the ground due to said twisting of the chassis (5) from exceeding the predetermined level is established by the electronic control device (40) based on the prevailing value of the slewing angle (θ); and

- **that** the electronic control device (40) sets the lifting moment limit value (M_{max}) to correspond to said adjusted lifting moment limit value ($M_{C,t}$) if said one or more stability conditions are fulfilled and to correspond to the lowest of said reduced value ($M_{C,red}$) and said adjusted lifting moment limit value ($M_{C,t}$) if said one or more stability conditions are not fulfilled.

6. A method according to claim 5, **characterized in that** said adjusted lifting moment limit value ($M_{C,t}$) is established as the product of said base value ($M_{C,base}$) and a reduction factor (κ_t), which is established by the electronic control device (40) by means of a calculation model or look-up table with the slewing angle (θ) as input value.

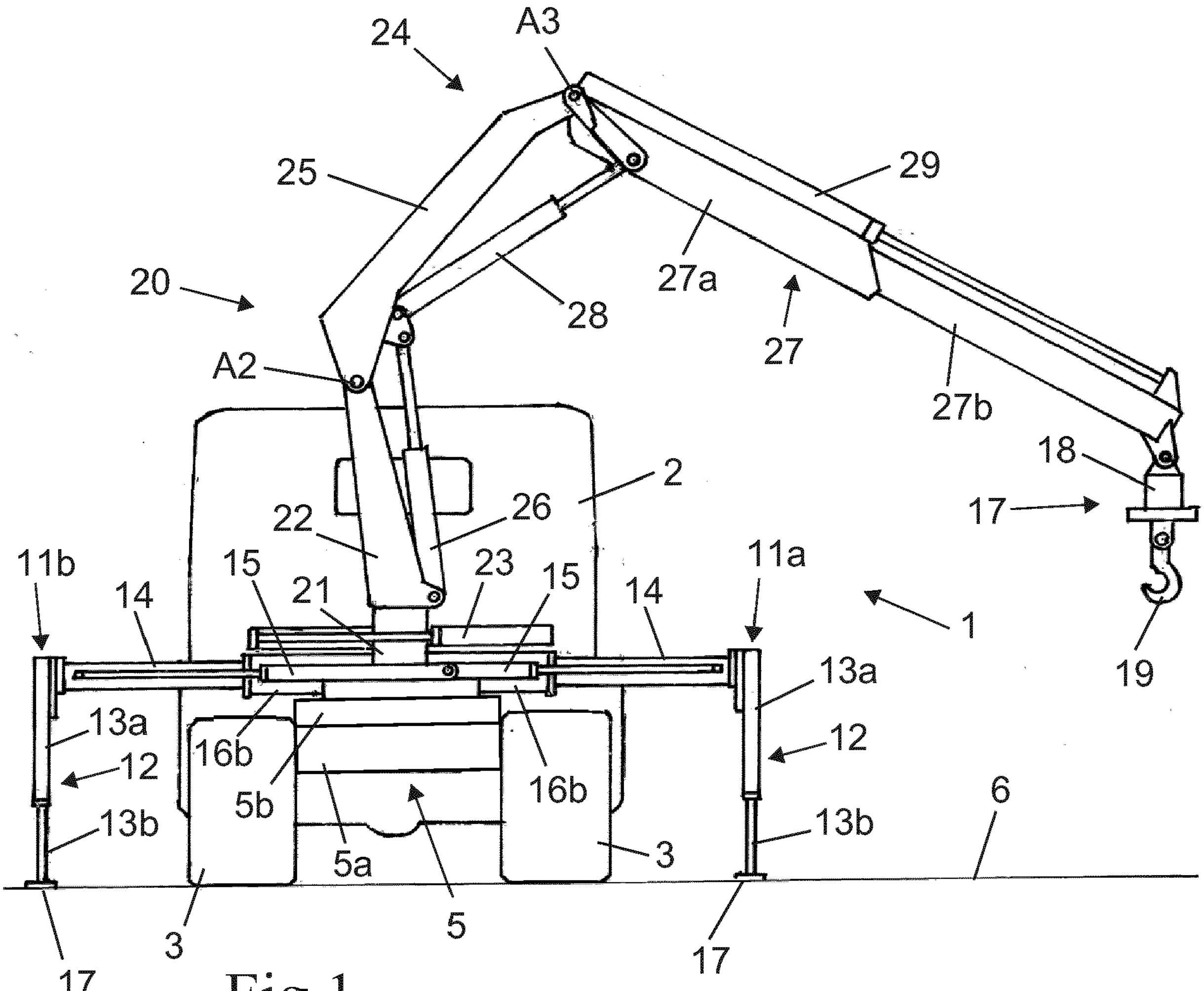
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Fig 1

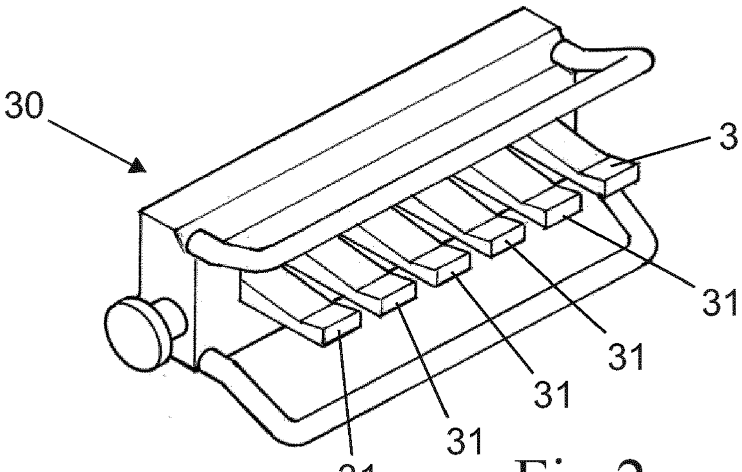
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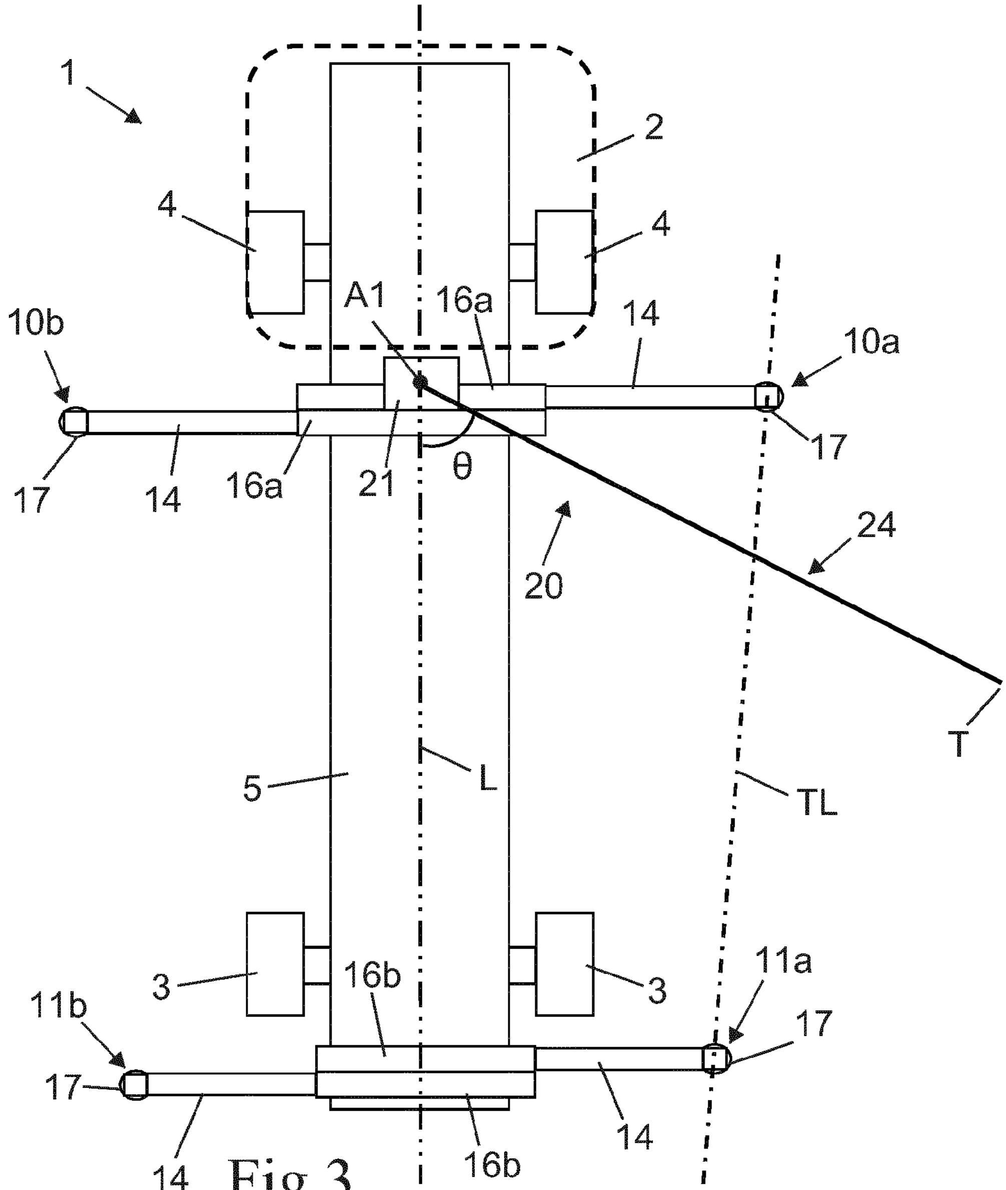
Fig 2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16b
11a
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16b

Fig 3

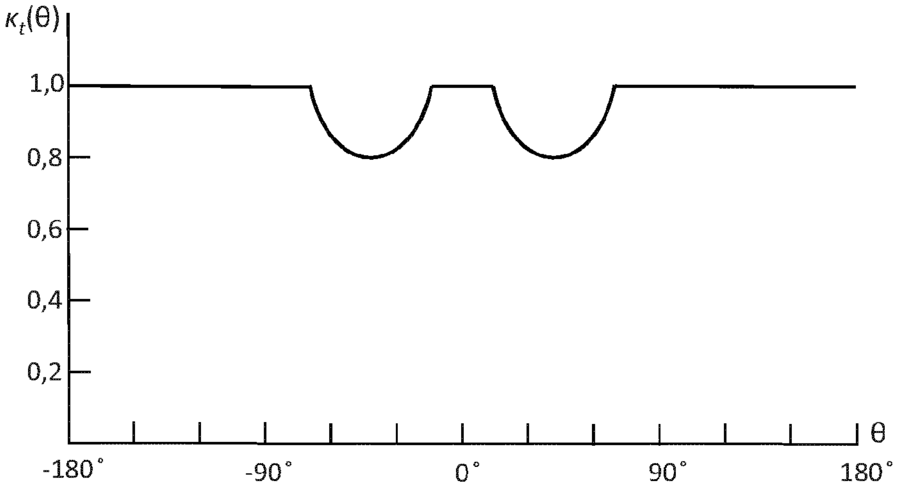
$\kappa_t(\theta)$
1,0
0,8
0,6
0,4
0,2
θ
-180°
-90°
0°
90°
180°

Fig 4

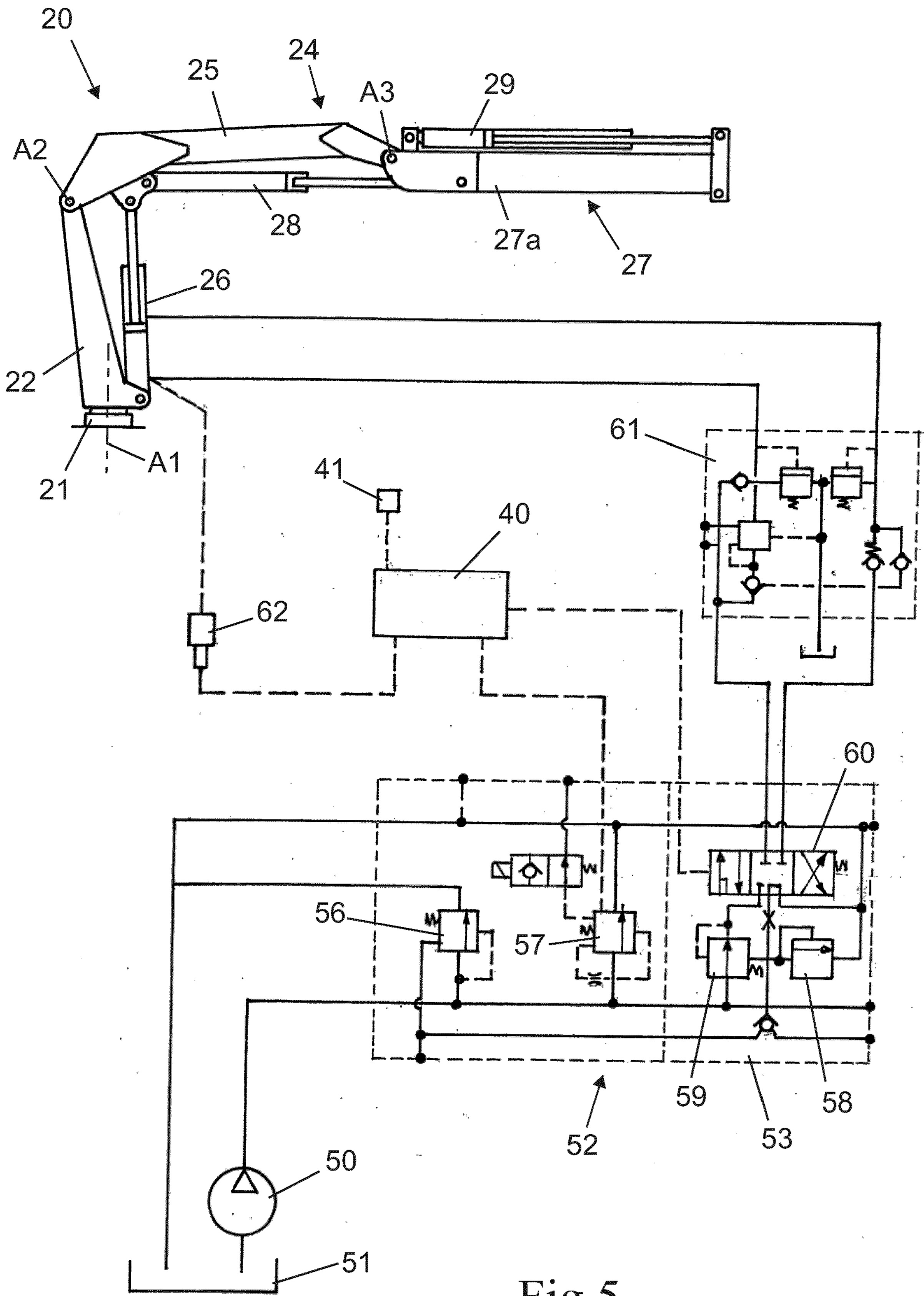
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Fig 5

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EUROPEAN SEARCH REPORT

Application Number
EP 19 20 4506

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,D	EP 2 298 689 A2 (CARGOTEC PATENTER AB [SE]) 23 March 2011 (2011-03-23) * paragraph [0011] - paragraph [0020]; claims 1,2,7,8; figures * -----	1-6	INV. B66C23/68 B66C23/80 B66C23/90
A	CN 203 922 532 U (XCMG XUZHOU TRUCK MOUNTED CRANE CO LTD) 5 November 2014 (2014-11-05) * abstract; figures * -----	1,4	
A	JP H06 63577 U (N.A.) 9 September 1994 (1994-09-09) * abstract; figures * -----	1,4	

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	7 April 2020	Popescu, Alexandru

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07-04-2020

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 2298689 A2	23-03-2011	EP 2298689 A2 SE 0901212 A1	23-03-2011 23-03-2011
CN 203922532 U	05-11-2014	NONE	
JP H0663577 U	09-09-1994	NONE	

EPO FORM P0459

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

- EP 2298689 B1 **[0005] [0034]**