

CRANE HAVING A CRANE CONTROLLER

The invention relates to a crane according to the preamble of claim 1 and a vehicle having such a crane.

Generic cranes having a crane controller which is configured, in an operating mode, to
5 carry out a coordinate control of the arm system are known in the state of the art.

During a conventional operation of a crane, in which the individual actuators of the arm system are individually actuated directly by a user or operator through control commands issued by him or her, the movement of the crane tip of the arm system results from the individual actuation movements controlled by the user. A movement of the crane tip of the
10 arm system along approximately an ideal vertical path thus requires a complex issuing of individual control commands by the user.

During a coordinate control of the arm system, on the other hand, the individual actuators of the arm system are actuated by the crane controller such that the user actuates the behaviour of the crane tip of the arm system instead of the individual actuators themselves.
15 Embodiments of coordinate controls are known in which the crane is controlled by the user essentially with only two operating elements (e.g. joysticks), one for pivoting the crane column and one for carrying out a horizontal movement and a vertical movement of the crane tip.

Because of the high complexity of some arm systems, which can comprise for example a
20 crane column, a main arm (also called lifting arm) arranged pivotable on the crane column and an articulated arm, arranged pivotable on the main arm, with a extension arm mounted displaceable therein, the arm system can have more degrees of freedom than are necessary at the least for the positioning and orientation of the crane tip in space. Thus, the crane column of a generic crane is mounted pivotable over a structurally predefined crane
25 column pivoting range and has one degree of freedom due to its pivotable mounting. The main arm is mounted on the crane column pivotable over a structurally predefined main arm pivoting range and has one degree of freedom due to its pivotable mounting. The articulated arm is mounted on the main arm pivotable over a structurally predefined articulated arm pivoting range and has one degree of freedom due to its pivotable

mounting. The at least one extension arm is mounted in the articulated arm displaceable over a structurally predefined pushing range and has one degree of freedom due to its displaceable mounting. The arm system of a generic crane therefore has four degrees of freedom. In the state of the art, such arm systems are known for example as redundant or
5 overdetermined manipulators.

With each specification of a path which the crane tip is to follow during a coordinate control, an infinite number of joint trajectories – thus in turn paths which the joints of the arm system are to follow – can thereby be possible. The excess movability due to the overdetermination is often used to optimize, for example, the movement sequence of the arm system or to
10 avoid obstacles.

During such a named control, after the specification of a desired path of the crane tip, thus after issue of a corresponding control command by the user (for example movement of the crane tip in Cartesian coordinates), a so-called reverse transformation or kinematic inversion is usually carried out by a processor or a processing unit of the crane controller,
15 from which the control commands, suitable for the desired path, for actuating the actuators of the arm system result (for example movement of the arm system along the degrees of freedom of the joints). In order to achieve an unambiguous solution for such a reverse transformation for an overdetermined arm system, the reverse transformation for generating control commands for the arm system must be effected taking into account
20 optimization criteria (such as for example so-called cost functions with weighting matrices) and optionally using approximations, and is associated with a large computing effort. During an actuation of the arm system effected in such a way, movements of the arm system of the crane that are not directly foreseeable for the operator can occur.

The object of the invention is to specify a crane with a crane controller which is configured,
25 in an operating mode, to carry out a coordinate control of the arm system, as well as a vehicle with such a crane, in which the operator can influence the movement of the arm system in order to prevent unforeseen movements and in which the complexity of calculating the reverse transformation is reduced.

This object is achieved by a crane with the features of claim 1 and a vehicle with such a
30 crane. Advantageous embodiments of the invention are defined in the dependent claims.

In a crane according to the invention it is provided that the crane controller has a user interface, wherein the user interface has at least one function that can be chosen by a user and through which at least one of the degrees of freedom is limitable or limited in the coordinate control operating mode.

- 5 Through the limitation of at least one of the degrees of freedom of the arm system, in the coordinate control operating mode unforeseeable movements of the arm system can be prevented and the complexity of calculating the reverse transformation can be greatly reduced.

10 The movements of the arm system can be more foreseeable for the user through the limitation of at least one of the degrees of freedom by the at least one function that can be chosen by a user. A user can thus, for example by selecting a corresponding function, limit and/or disable, in a targeted manner, degrees of freedom of the movement of the arm system which the user does not wish to be involved in the movement of the arm system in the coordinate control operating mode.

- 15 Because a user can select at least one function for limiting at least one of the degrees of freedom of the arm system, the movements of the arm system can be adapted in a targeted manner to the planned lifting process. The user can thus be given the possibility of interacting with the crane, whereby the user can influence the functioning of the crane.

20 In an embodiment of the invention, the user can thereby be given the possibility of selecting the arms of the arm system involved in the coordinate control. In a further development of this embodiment of the invention, a user can additionally be given the possibility of preferring or prioritizing different combinations of arms of the arm system that are involved in the coordinate control.

25 Because a user interface is provided, the selection of the at least one function can be easily made possible for the user.

According to a preferred embodiment example, it can be provided that the arm system additionally has a second articulated arm, which is mounted on the extension arm pivotable over a structurally predefined second articulated arm pivoting range and has one degree of

freedom due to its pivotable mounting, and which preferably comprises at least one second extension arm, which is mounted in the second articulated arm displaceable over a structurally predefined second extension arm pushing range and has one degree of freedom due to its displaceable mounting. The second articulated arm expands the space of the possible positioning of the crane tip and is often also referred to as a so-called “fly jib”.

It can preferably be provided that the arm system additionally has at least one main arm extension arm, which is mounted in the main arm displaceable over a structurally predefined extension range and has one degree of freedom due to its displaceable mounting. Due to the at least one main arm extension arm, the main arm can be formed telescopic.

In a preferred embodiment, it can be provided that at least one additional device in the form of an implement and/or an arm extension, preferably an arm extension that is static and optionally can be arranged at a predefinable angle, is arranged on the arm system.

In principle, taking the geometric data of additional devices or attachments into account in the calculation is not a problem for the coordinate control. For this, the coordinate control need only be supplied with information about an additional device attached to the arm system (e.g. information about the function range, dimension data, angular positions), with the result that this information can be incorporated in the calculation.

It can therefore be provided that information, preferably information about the function range and/or dimension data and/or angular positions, for the at least one additional device can be transferred to the crane controller via the user interface, wherein the information can be selected from a database stored in a memory of the crane controller and/or can be input via the user interface, preferably via a setup screen. Thus, for example, information already stored in the crane controller about an additional device can be selected via a menu or information can be input by the user via a setup screen. The setup state of the crane can thereby be configured correctly and it can be made possible for a coordinate control of the tip of the additional device to be carried out in the coordinate control operating mode. In order to ensure the setup state of the crane, a safety query can be provided. Thus, it can be provided that the user has to confirm the setup state of the crane via the user interface by selecting a corresponding function of the user interface.

It can preferably be provided that the crane controller is configured to carry out a coordinate control of the crane tip or of a predefined or predefinable point of the arm system or a predefined or predefinable point supported by the arm system. In the coordinate control operating mode, a coordinate control of the crane tip is carried out in most cases. Instead of
5 the crane tip, however, any other point of the arm system or a point supported by the arm system can also be used, for which a coordinate control is carried out. Thus, a cable winch could be arranged on the arm system and a coordinate control could be carried out in relation to the attachment point of the cable winch on the arm system or in relation to the load hook on the cable end of the cable winch. It can thereby be provided, during a cable
10 winch operation, that the coordinate control is no longer based on the crane tip itself, but directly controls the position of the load at the cable end. The switch from a coordinate control of the crane tip to a coordinate control of a predefined or predefinable point of the arm system or a predefined or predefinable point supported by the arm system can be detected by the crane controller and proposed to the operator, who can or must confirm this
15 switch. It can also be provided that this switch can be activated by the operator by selecting a corresponding function of the user interface.

As the kinematics of a generic crane, which can be a loading crane, are overdetermined for the coordinate control owing to the degrees of freedom of the arm system that are present, restrictions and/or specifications must be made for an unambiguous solution of the reverse
20 transformation, in order to resolve or reduce this overdetermination. The limitation of the degrees of freedom of the arm system represents a suitable restriction.

In a particularly preferred embodiment, it can therefore be provided that at least one degree of freedom of the arm system is limitable or limited by the at least one function that can be chosen by the user, in order to nullify or reduce an overdetermination of the arm system.
25 Through a nullification of the overdetermination or redundancy of the arm system, the complexity of calculating the reverse transformation, from which the control commands, suitable for the desired path, for actuating the actuators of the arm system result, can be greatly reduced.

It can be provided that the degree of freedom of the rotatable crane column is excluded
30 from the quantity of limitable or limited degrees of freedom to retain the pivotability of the crane column. This makes sense in particular in embodiments of coordinate controls in

which the crane is controlled by the user with two operating elements (e.g. joysticks), wherein one of the two operating elements is used to pivot the crane column and the other operating element is used to carry out a horizontal movement and a vertical movement of the crane tip.

- 5 Retaining the pivotability of the crane column can be desirable, for example, if this degree of freedom of the movement of the arm system is present in a non-redundant manner.

The fact that the degree of freedom of the rotatable crane column is excluded from the quantity of limitable or limited degrees of freedom to retain the pivotability of the crane column can be advantageous in particular in the case of supporting situations of the crane
10 in which the axis of rotation of the pivotable crane column deviates from the vertical.

It can preferably be provided that, through the at least one function that can be chosen by the user, one degree of freedom of the arm system is limitable or limited or all degrees of freedom of the arm system except for two degrees of freedom are limitable or limited. During a coordinate control of the arm system in which the coordinate control can be carried
15 out by actuation of main arm, articulated arm and extension arm, the limitation of one degree of freedom is sufficient to nullify or reduce an overdetermination of the arm system, as precisely two degrees of freedom are left over after the limitation of one degree of freedom, in order to carry out a horizontal movement and a vertical movement of the arm system. If the arm system comprises additional arms (e.g. a second articulated arm), the
20 limitation of all degrees of freedom of the arm system except for two degrees of freedom is sufficient to nullify or reduce an overdetermination of the arm system, as precisely two degrees of freedom are left over after such a limitation of the degrees of freedom, in order to carry out a horizontal movement and a vertical movement of the arm system. In other words, the coordinate-controlled movements of the arm system are thereby implemented
25 with only two arms or crane sections or degrees of freedom, whereby these movements are unambiguously determined and easier for the user to understand. Moreover, unforeseeable movements of the arm system can be prevented by limiting one degree of freedom or the degrees of freedom of an undesired arm.

According to a particularly preferred embodiment, it can be provided that the crane
30 controller is configured, in the coordinate control operating mode, to use an arm selection in

the form of a subset of the arms of the arm system to carry out the coordinate control of the arm system, wherein the crane controller has at least one operating profile, in which at least two arm selections are stored in a predefined or predefinable ranking from a higher prioritization to a lower prioritization or are determined continuously, and the crane controller is configured to use and actuate the arm selections stored in the at least one operating profile according to their prioritization for carrying out the coordinate control of the arm system, wherein the at least one operating profile can be selected through the at least one function that can be chosen by the user. A continuous determination can be effected during operation depending on the current position of the arm system or the suitability of an arm selection for the lifting movement carried out or to be carried out.

It can preferably be provided that each of the at least two arm selections consists of two arms of the arm system.

One of the operating profiles can be, for example, a so-called default prioritization, which is always used when no other operating profile is selected specifically or in a targeted manner. The following Table 1 shows an example of such a default prioritization for a crane with an arm system which, in addition to main arm, articulated arm and extension arm, comprises a second articulated arm and a second extension arm. The operating profile represented in the table comprises 10 arm selections with different prioritizations. In the table, the prioritization with the number 1 represents the highest prioritization and the prioritization with the number 10 represents the lowest prioritization.

In the following tables, the arms of the arm system are abbreviated as follows: HA corresponds to the main arm, KA corresponds to the articulated arm, SA corresponds to the extension arm (of the articulated arm), JKA corresponds to the second articulated arm, JSA corresponds to the second extension arm (of the second articulated arm).

Table 1

Prioritization	Arm selection
1	KA + SA
2	HA + SA
3	HA + KA

4	JSA + JKA
5	HA + JSA
6	KA + JSA
7	SA + JKA
8	KA + JKA
9	HA + JKA
10	SA + JSA

According to a preferred embodiment, it can be provided that the crane controller is configured to use an arm selection for the coordinate control depending on a predefinable and/or a predefined and/or a prevailing position of the arm system.

- 5 It can preferably be provided that the crane controller is configured in order that the use and actuation of an arm selection from the at least two arm selections is additionally effected depending on the ability of the coordinate control to be carried out with the respective arm selection.

- Thus, for example, if the default prioritization represented by way of example in Table 1 is used, the arm selection with the prioritization 1 (articulated arm and extension arm) could be used for the coordinate control first depending on the position of the arm system and on the ability of the coordinate control to be carried out. If the movement desired by the user is not possible with this arm selection, the arm selection with the next prioritization down, thus prioritization 2 (main arm and extension arm), would be used for the coordinate control.
- 10 This would continue along the prioritizations until an arm selection with which the movement desired by the user can be carried out is found.
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- It can also be provided that, depending on the arms or crane sections present, different operating profiles are stored. Thus, in the case of a crane with an arm system comprising main arm, articulated arm, extension arm, second articulated arm and second extension arm, for example, a first operating profile can be stored, the arm selections of which comprise only main arm and/or articulated arm and/or extension arm, and a second operating profile can be stored, the arm selections of which are subsets of all arms present.
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Table 2 represented below shows by way of example a first operating profile and Table 3

represented below shows by way of example a second operating profile.

The first operating profile, represented in Table 2, comprises 3 arm selections with different prioritizations. In the table, the prioritization with the number 1 represents the highest prioritization and the prioritization with the number 3 represents the lowest prioritization.

- 5 The second operating profile, represented in Table 3, comprises 10 arm selections with different prioritizations. In the table, the prioritization with the number 1 represents the highest prioritization and the prioritization with the number 10 represents the lowest prioritization.

Table 2

Prioritization	Arm selection
1	HA + KA
2	KA + SA
3	HA + SA

Table 3

Prioritization	Arm selection
1	HA + KA
2	KA + SA
3	HA + SA
4	HA + JKA
5	HA + JSA
6	KA + JKA
7	KA + JSA
8	SA + JSA
9	SA + JKA
10	JKA + JSA

- 10 With reference to the first operating profile according to Table 2, a possible use of this operating profile is explained below by way of example. If the movement of the arm system desired by the user is possible with the highest-priority arm selection, thus prioritization 1 (main arm and articulated arm), this arm selection is always used to carry out the

coordinate control of the arm system. If one of the arms of the arm selection reaches the limit of travel or is otherwise blocked, the arm selection with the next prioritization down is used. Should the arm selection with the prioritization 1 become available again in the course of the movement of the arm system (i.e. the movement desired by the user were to be possible again with this arm selection), the process will still continue with the currently used arm selection, in order to avoid a constant changing of the arm selections used for carrying out the coordinate control. Not until a re-start of the movement (after a neutral position of the lever) or a switch of the arm selection again owing to a limit of travel or blocking is the arm selection with the prioritization 1 taken into consideration again. Thus, in the case of this use of the first operating profile according to Table 2, for example, the following sequence can result:

1. Start with the arm selection with the prioritization 1 (main arm and articulated arm), as all arm selections of the operating profile are possible and this arm selection has the highest prioritization.
2. Main arm reaches the limit of travel.
3. Switch to the next possible prioritization, e.g. arm selection with the prioritization 2 (articulated arm and extension arm).
4. Arm selection with the prioritization 1 (main arm and articulated arm) available again, the arm selection with the prioritization 2 (articulated arm and extension arm) remains active.
5. Extension arm reaches the limit of travel.
6. Switch to arm selection with the prioritization 1 (main arm and articulated arm) if possible, stop if not.

It can be provided that the ranking of the at least two arm selections of an operating profile is alterable. In particular, the ranking can be determined continuously.

Table 4 represented below shows by way of example a further operating profile. This comprises 3 arm selections with different prioritizations. In the table, the prioritization with the number 1 represents the highest prioritization and the prioritization with the number 3 represents the lowest prioritization.

Table 4

Prioritization	Arm selection
1	KA + SA
2	HA + SA
3	HA + KA

Supplementing the use of the operating profile shown in Table 4, in the example explained below for the degree of freedom of the pivoting movement of the main arm a target angle of 20° was set, for example by a corresponding function of the user interface for setting the target angle of the main arm having been selected.

The crane is moved in a coordinate-controlled manner using the arm selections of the operating profile according to Table 4 and, in the course of the movement of the arm system, the main arm departs from its target angle and is at an angular position of 50°. Subsequently, owing to a limit of travel or a re-start of the movement, a switch of the arm selection occurs. After that, the two arm selections which comprise the main arm (thus the arm selection with the prioritization 2 and the arm selection with the prioritization 3) are evaluated by the crane controller as to whether the target angle of the main arm can be arrived at again with the current user specification. Thereafter, the arm selection which moves the main arm back into its target angular position the quickest is temporarily put in first place (or obtains the prioritization with the number 1). When the target angle of the main arm is reached, the arm selection temporarily put in first place is put back to its original position according to Table 4 (or obtains its original prioritization again).

In a preferred embodiment, it can be provided that the limitation of the at least one degree of freedom is effected in that it is settable or set to a predefined or predefinable value and/or is restrictable or restricted to a predefinable or predefined partial range and/or restrictable or restricted in relation to its rate of change.

It can therefore be provided that at least one arm of the arm system can be blocked through the at least one function that can be chosen by the user. In other words, at least one arm of the arm system can thus be temporarily blocked, with the result that this at least one blocked arm no longer participates in the coordinate-controlled movement of the arm system, and instead remains in its blocked position. However, the fact that the at least one

blocked arm no longer participates in the coordinate-controlled movement of the arm system is not intended to mean that it remains, for example, stationary in space, but rather that the degree or degrees of freedom of the at least one blocked arm are no longer used for moving the arm system.

- 5 For the crane, it can be provided that the user interface comprises at least one operating element (for example a knob, a linear lever or an axis of a multi-axis joystick) of the crane controller and a selection of the function that can be chosen is effected through an actuation of the at least one operating element by a user.

- 10 In principle, it can be provided that the crane controller is configured, in a further operating mode, to carry out a free control of the arm system. This can correspond to a conventional operation of a crane in which the individual actuators of the arm system are individually actuated directly by a user through control commands issued by him or her.

- 15 In such a further operating mode, a free actuation of the arm system can be effected by at least one operating element of the crane controller, wherein in each case one operating element is provided for the input of control commands for moving in each case one arm of the arm system along one degree of freedom. Thus, in each case, one operating element (for example a linear lever assigned to the movement or one axis of a multi-axis joystick) can be provided for the free actuation of the arm system for the respective movement of one arm of the arm system along its respective degree of freedom.

- 20 It can be provided that, through an actuation (for example by movement in a particular direction) of the at least one operating element by a user, while the crane controller is in the coordinate control operating mode, the degree of freedom of the arm system assigned to the operating element in the above-described further operating mode is limitable or limited. The assignment of the function of the at least one operating element in the further operating mode for the free actuation of the arm system can be used in the coordinate control
25 operating mode for a selection of a limitation of the corresponding degree of freedom of the movement of the arm system.

Analogously thereto, it can be provided that a limitation can be nullified again by a corresponding actuation (for example by a movement in the opposite direction) of the

operating element.

Thus, for example, the main arm (or any other arm of the arm system) can be blocked, in order to simplify the movement sequence for the user. For the blocking as well as for the nullification of the blocking of an arm, an input device of the user interface can be used, such as for example a button of a menu-driven user interface or operating elements such as for instance a lever of a lever-operable user interface. In addition to the input devices for the coordinate control operating mode, a user interface of a crane controller for a crane often also has individual operating levers (for instance a joystick with for example two orthogonal axes or single-axis linear levers) for a free control of the arm system in a further operating mode. These operating levers, which are not used to control the arm system in the coordinate control operating mode, can be used for the blocking as well as for the nullification of the blocking of an arm. Thus, for example, the main arm can be blocked via the operating element not used in the coordinate control for the main arm movement (for example the main arm lever).

The user can position the main arm in a desired position and then fix the main arm angle. For this purpose, it can be provided that the user only has to deflect the operating element assigned to the main arm movement (for instance a joystick with for example two orthogonal axes or a single-axis linear lever) in one direction and can thus activate the movement block. All further coordinate-controlled movements of a crane with main arm, articulated arm and extension arm are then carried out only with articulated arm and extension arm. In addition, a visualization on a display of the crane controller can be effected, in which blocked arms or crane sections are correspondingly marked. If the operator actuates the operating element assigned to the main arm movement again (e.g. in the opposite direction), he or she can very conveniently nullify the blocking or fixing of the main arm again. Such a blocking or fixing can be effected in an analogous manner for every other arm or every degree of freedom of the movement of the arm system.

As an example, the main arm can be positioned high (e.g. 70° - 80°) and then blocked. The coordinate-controlled crane movements are thus carried out only with articulated arm and extension arm, and a very large range of movement can thus be covered. In addition, the main arm can thus be prevented from colliding with structures on a carrier vehicle or a truck on which the crane is installed due to unforeseen movements.

It can preferably be provided that, through a limitation of the at least one degree of freedom, the degree of freedom of the articulated arm is restrictable or restricted to a predefinable or predefined partial range, preferably to a predefinable or predefined quadrant, with the result that, in the coordinate control operating mode, the articulated arm is positionable or positioned in an overextended pivot position above an imaginary extension of the main arm.

An imaginary extension of the main arm (main arm line) and an imaginary line running perpendicularly thereto through the pivot bearing of the articulated arm on the main arm (pivot bearing line) form four regions or quadrants. Quadrant 1 denotes the region between the main arm line and the pivot bearing line above the main arm line and in the direction of the imaginary extension of the main arm. Quadrant 2 denotes the region between the main arm line and the pivot bearing line above the main arm line and in the direction of the main arm. Quadrant 3 denotes the region between the main arm line and the pivot bearing line underneath the main arm line and in the direction of the main arm. Quadrant 4 denotes the region between the main arm line and the pivot bearing line underneath the main arm line and in the direction of the imaginary extension of the main arm.

An absence of conventional coordinate controls is the lack of an unambiguous solution for the so-called overextension of the articulated arm, in which the articulated arm is to move from a pivot position underneath an imaginary extension of the main arm (quadrant 4) to a pivot position above the imaginary extension of the main arm (quadrant 1). In particular, there is a discontinuity in the calculation at the dead centre (the articulated arm angle is 0° , i.e. the articulated arm is arranged in an exactly straight extension relative to the main arm).

One possibility would be to overextend the articulated arm with the aid of a manual override, by selecting a corresponding function of the user interface.

However, it can also be provided that the crane controller, in the coordinate control operating mode, provides an assistance function, through which, when approaching the dead centre, the articulated arm is moved starting from quadrant 4 into quadrant 1 and the degree of freedom of the articulated arm is restricted to quadrant 1. As soon as the articulated arm is located in quadrant 1, it will move only in this quadrant, in order to keep the calculation unambiguous. The transition from an overextended pivot position of the articulated arm (pivot position above the imaginary extension of the main arm) to a pivot

position underneath the imaginary extension of the main arm can be effected correspondingly in reverse. It can be provided that the assistance function can be selected through the at least one function that can be chosen by the user.

In an embodiment example of the invention, it can be provided that the predefinable or predefined partial range is smaller than or equal to 2° , preferably smaller than or equal to 0.5° , or is smaller than or equal to 10 cm, preferably smaller than or equal to 2.5 cm, and/or the rate of change is smaller than or equal to 0.2° per second, preferably smaller than or equal to 0.05° per second, or is smaller than or equal to 2 cm per second, preferably smaller than or equal to 0.5 cm per second. A limitation of one of the degrees of freedom of the arm system can thus correspond to a greatly decelerated movement of a respective arm along a respective degree of freedom. During an actuation of the arm system in the coordinate control operating mode, an arm correspondingly limited in its movement or a correspondingly limited degree of freedom can be regarded by a user as substantially uninvolved in the movement of the arm system. From the user's point of view, substantially no unforeseeable movements thus result.

According to a preferred embodiment, it can be provided that the crane controller has a, preferably portable, control panel and the user interface is formed on the control panel. The control panel can have a display and operating elements in the form for instance of a knob, a linear lever and a push button. The operating elements can be used to navigate the menu-supported user interface, to select the function that can be chosen by a user or to issue control commands by a user.

By a portable control panel can be meant a standalone operating unit with which a user can move substantially freely in a certain periphery around a crane or a hydraulic lifting device. Of course, data and information can be exchanged between such a control panel and the crane or the hydraulic lifting device, for example via radio and/or cable-supported connections.

It can preferably be provided that the user interface is menu-driven and/or comprises at least one operating element of the crane controller. The menu-driven user interface can follow a hierarchical structure. It is conceivable that the menu items of the user interface can be graphically modelled and represented. A menu-driven user interface can make it

possible for a user to select different functions, for example from a list of predefined or predefinable functions.

According to a preferred embodiment, it can be provided that the crane controller comprises a display. If the display of the crane controller is implemented as a touch display, then the user interface can be implemented directly via the touch display. For example, by touching a crane arm, represented on the display, of an arm system represented once, the corresponding degree of freedom can be limited. On the display, to visualize the limitation of the degree of freedom, for example the colour of the crane arm represented can change from white to black. If the crane arm is touched a further time, this limitation can be nullified again and the display of the crane arm can for example change back from black to white. If the display is not implemented as a touch display or the like, the optionally menu-driven user interface can be navigated via an operating element of the crane controller. The display can take on the function of a status display for the operator, on which it is recognizable at a glance which crane arms or degrees of freedom are limited.

In a preferred embodiment, it can be provided that the crane controller is configured, in a further operating mode, to carry out a free control of the arm system on the basis of control commands input by a user, wherein, starting from the coordinate control operating mode, a switch to the further operating mode is effected for as long as a predefinable or predefined operating element of the crane controller, preferably a dead man's switch of the crane controller, remains actuated by a user. It can thus be possible for a user to switch from the coordinate control operating mode to the further operating mode for freely controlling the arm system temporarily by actuating an operating element of the crane controller provided for this. For example, individual arms of the arm system can thereby be brought into a desired position in a targeted manner and freely or obstacles can be driven manually.

In the further operating mode for freely controlling the arm system, the crane geometry, i.e. the position of the crane arms relative to each other in a plane or relative to the crane column and the pivot position of the crane arms together with the crane column relative to a crane base, can be freely altered by a user. The user can, for example by actuating corresponding operating elements, change the relative position of the crane arms and pivot the crane arms together with the crane column relative to the crane base. In the background, the crane operation is usually monitored by safety devices which engage

when operating elements which lead to a safety-critical situation are actuated by the user. For example, the stability of the crane can be monitored.

Generally, it can be provided that the crane controller has several operating modes. Thus, in addition to the coordinate control operating mode and a further operating mode for freely
 5 controlling the arm system, for example there can also be a working position operating mode, in which the crane geometry is alterable in a predetermined sequence of movements by the crane controller, in order to bring the crane into a predetermined working position and/or into a predetermined parking position in a simple manner. The crane controller can also be configured in order that it memorizes the last-used operating mode before the crane
 10 is folded into its parking position. Thus, it can be provided that, after the crane has been unfolded into its working position by means of the working position operating mode the coordinate control operating mode is automatically switched to, if the coordinate control operating mode was active last before the crane was folded into its parking position.

Protection is also sought for a vehicle with a crane of the above-described type. The vehicle
 15 can be a truck and the crane can be a loading crane.

Embodiment examples of the invention are discussed with reference to the figures. There are shown in:

	Figs. 1a to 1c	side views of different embodiments of a crane installed on a vehicle,
	Figs. 2a to 2c	side views of different embodiments of a crane,
20	Figs. 3a to 3e	side views for degrees of freedom of the movement of different arms of different arm systems,
	Fig. 4	an embodiment of a crane with a length-adjustable main arm,
	Figs. 5a and 5b	two embodiments of additional devices that can be arranged on the arm system,
25	Figs. 6a and 6b	side views of different embodiments of a crane and in each case a schematic representation of a crane controller with a sensor system,
	Fig. 7	an example display of the crane controller of a proposed crane with selection possibilities for operating modes displayed thereon,
	Figs. 8a to 8c	example embodiments of user interfaces,
30	Figs. 9a to 9c	show possible application examples which make use of operating

- profiles,
- Figs. 10a to 10e embodiments of user interfaces,
- Figs. 11a to 11d further embodiments of user interfaces and an input screen,
- Fig. 12 a possible limitation of the degree of freedom β of the articulated arm,
- 5 Fig. 13a the display of a crane controller of a proposed crane,
- Fig. 13b a control panel of the crane controller according to Figure 13a, and
- Fig. 14 a further embodiment of a user interface.

Side views of different embodiments of a crane 1 installed on a vehicle 19 are shown in Figures 1a to 1c. Figures 2a to 2c show the cranes 1 of Figures 1a to 1c in isolation. The
 10 degrees of freedom α , β , φ , γ , L, J, H of the movement of the individual arms 2, 3, 4, 5, 7, 8, 24 of the different arm systems of the cranes 1 are illustrated in Figures 3a to 3e and in Figure 4.

A first embodiment of a proposed crane 1 is shown in Figure 1a, wherein the crane 1 is formed as a loading crane or an articulated arm crane and is arranged on a vehicle 19. The
 15 crane 1, as shown, has a crane column 2 rotatable about a first vertical axis v1 by means of a slewing gear 20, a main arm 3 mounted on the crane column 2 pivotable about a first horizontal pivot axis h1 and an articulated arm 4 mounted on the main arm 3, pivotable about a second horizontal pivot axis h2, with at least one extension arm 5. A hydraulic main cylinder 21 is provided for pivoting the main arm 3 relative to the crane column 2
 20 (represented articulation angular position a1 of the degree of freedom α). A hydraulic articulated cylinder 22 is provided for pivoting the articulated arm 4 relative to the main arm 3 (represented articulation angular position b1 of the degree of freedom β). In this embodiment of the crane 1, the crane tip 14 can be formed by the tip of the extension arm 5.

25 The arm system of the crane 1 shown therefore has a crane column 2, a main arm 3, an articulated arm 4 and at least one extension arm 5.

The crane 1 has a schematically represented crane controller 6 which is configured, in a coordinate control operating mode, to carry out a coordinate control of the arm system. The crane controller 6 has a user interface, not represented in more detail here, wherein the
 30 user interface has at least one function that can be chosen by a user, through which at least one of the degrees of freedom α , β , φ , L (see Figures 3a to 3e and Figure 4) is limitable or

limited in the coordinate control operating mode.

A second embodiment of a proposed crane 1 is shown in Figure 1b, wherein the crane 1 shown therein, in addition to the equipment of the embodiment shown in Figure 1a, has a second articulated arm 7, arranged on the extension arm 5 of the articulated arm 4
5 pivotable about a third horizontal pivot axis h_3 , with a second extension arm 8 mounted therein. An articulated cylinder 23 is provided for pivoting the second articulated arm 7 relative to the articulated arm 4 (represented articulation angular position g_1 of the degree of freedom γ). In this embodiment of the crane 1, the crane tip 14 can be formed by the tip of the extension arm 8.

- 10 The arm system of the crane 1 shown in Figure 1b therefore has a crane column 2, a main arm 3, an articulated arm 4 with at least one extension arm 5, as well as a second articulated arm 7 with at least one extension arm 8.

Analogously to the embodiment of Figure 1b, for the crane 1 shown in Figure 1b, in the coordinate control operating mode, one of the degrees of freedom α , β , φ , γ , L , J (see
15 Figures 3a to 3e and Figure 4) can be limitable or limited through a function that can be chosen by a user.

A third embodiment of a proposed crane 1 is shown in Figure 1c, wherein the crane 1 shown therein, in addition to the configuration of the embodiment shown in Figure 1b, has a further articulated arm 24 attached to the second extension arm 8 of the second articulated
20 arm 7 pivotable about a fourth horizontal pivot axis a_4 . An articulated cylinder 25 is provided for pivoting the further articulated arm 24 relative to the second articulated arm 7 (represented articulation angular position d_1 of the degree of freedom of the pivoting movement of the further articulated arm 24). In this embodiment of the crane 1, the crane tip 14 can be formed by the tip of the further articulated arm 24.

- 25 The arm system of the crane 1 shown in Figure 1c therefore has a crane column 2, a main arm 3, an articulated arm 4 with at least one extension arm 5, a second articulated arm 7 with at least one extension arm 8, as well as a further articulated arm 24 (which can optionally be formed length-adjustable).

Analogously to the embodiments of Figures 1a and 1b, for the crane 1 shown in Figure 1c, in the coordinate control operating mode, at least one of the degrees of freedom α , β , φ , γ , L, J (see Figures 3a to 3e and Figure 4) as well as the degree of freedom of the pivoting movement of the further articulated arm 24 can be limitable or limited through a function
5 that can be chosen by a user.

All embodiments shown can of course have a slewing gear 20.

A detail view of a crane 1 formed according to Figures 1a to 1c is shown in each of Figures 2a to 2c.

The degrees of freedom α , β , φ , γ , L, J of the movement of different arms of different arm
10 systems are illustrated in side views in Figures 3a to 3e.

The crane 1 shown in Figures 3a to 3c corresponds in terms of design to those of Figures 1a and 2a. The articulated arm 7 shown in Figures 3e and 3b corresponds to that of the second articulated arms 7 in Figures 1b and 2b. The further articulated arm 24 of Figures 1c and 2c can equally be formed corresponding to the articulated arm 7 shown in Figures 3e and 3b.

15 With reference to Figures 3a to 3c, the crane column 2 rotatable about the axis of rotation in the form of the first vertical axis v_1 is mounted pivotable over a structurally predefined crane column pivoting range $\varphi_1 - \varphi_2$ and has one degree of freedom φ due to its pivotable mounting. It is conceivable that the crane column pivoting range extends over an interval of from 0° to 360° , thus the crane column is formed infinitely pivotable. The main arm 3
20 is mounted on the crane column 2 pivotable over a structurally predefined main arm pivoting range $\alpha_1 - \alpha_2$ and has one degree of freedom α due to its pivotable mounting. The articulated arm 4 is mounted on the main arm 3 pivotable over a structurally predefined articulated arm pivoting range $\beta_1 - \beta_2$ and has one degree of freedom β due to its pivotable mounting. The extension arm 5 is mounted in the articulated arm 4 displaceable over a
25 structurally predefined extension range $L_1 - L_2$ and has one degree of freedom L due to its displaceable mounting.

Figures 3d and 3e show in isolation an articulated arm 7 which can be mounted over a connecting region 28 on the extension arm 5 of the crane 1 of Figures 3a to 3c pivotable

over a structurally predefined second articulated arm pivoting range $\gamma_1 - \gamma_2$ and has one degree of freedom γ due to a pivotable mounting, and which comprises at least one second extension arm 8, which is mounted in the second articulated arm 7 displaceable over a structurally predefined second extension arm extension range $J_1 - J_2$ and has one degree of freedom J due to its displaceable mounting.

Figure 4 shows an embodiment of a crane 1 the arm system of which, unlike the previously discussed embodiments, additionally have at least one main arm extension arm 18, which is mounted in the main arm 3 displaceable over a structurally predefined (and only schematically represented) extension range $H_1 - H_2$ and has one degree of freedom H due to its displaceable mounting.

The arm system of the crane 1 shown in Figure 4 therefore has a crane column 2, a main arm 3 with at least one main arm extension arm 18, an articulated arm 4 with at least one extension arm 5.

Analogously to the previously discussed embodiments, for the crane 1 shown in Figure 4, in the coordinate control operating mode, at least one of the degrees of freedom α , β , φ , H , L can be limitable or limited through a function that can be chosen by a user.

As represented in Figures 3a to 3e and 4, the degrees of freedom α , β , φ , γ , L , J , H of the movement of different arms can be settable or set to a predefined or predefinable value α_0 , β_0 , φ_0 , γ_0 , L_0 , J_0 , H_0 , and/or can be restrictable or restricted to a predefinable or predefined partial range $\alpha_1 < \alpha_3 - \alpha_4 < \alpha_2$; $\beta_1 < \beta_3 - \beta_4 < \beta_2$; $\varphi_1 < \varphi_3 - \varphi_4 < \varphi_2$; $\gamma_1 < \gamma_3 - \gamma_4 < \gamma_2$; $L_1 < L_3 - L_4 < L_2$; $J_1 < J_3 - J_4 < J_2$; $H_1 < H_3 - H_4 < H_2$.

Two embodiments of additional devices that can be arranged on the arm system are shown in Figures 5a and 5b, in the form of an implement 9, designed by way of example as a brick stack grapple, and a static arm extension 10.

An embodiment of an implement 9 which can be arranged on a extension arm of a crane is shown in Figure 5a. Dimensions and function range of the implement can be stored in a crane controller, not represented here, and taken into account in the calculations of the crane controller.

The static arm extension 10 represented in Figure 5b can be arranged on a extension arm of a crane via a corresponding receiver. Through a receiver that is formed adjustable, the arm extension 10 can be arranged on a extension arm at an angle ϑ (here plotted compared with an imaginary vertical). The arm extension 10 can be formed length-adjustable. The information about the arm extension 10, such as for instance the length of the arm extension 10 and the angle ϑ , can be stored in a crane controller, not represented here, and taken into account in calculations of the crane controller, specifically in relation to the position of the crane tip (regarding this see Figures 11b and 11d).

An embodiment of the crane 1 according to Figures 1a and 2a is shown in Figure 6a. In addition, a schematic representation of the crane controller 6 is shown which is configured, in a coordinate control operating mode, to carry out a coordinate control of the arm system. The crane controller 6 has a user interface, not represented in more detail here, wherein the user interface has at least one function that can be chosen by a user, through which at least one of the degrees of freedom α , β , φ , L is limitable or limited in the coordinate control operating mode.

The crane controller 6 represented schematically here has several signal inputs to which signals of the sensor system built into the crane 1 can be fed. Furthermore, the crane controller 6 has a memory 11, in which for example program data for operating modes and calculation models of the crane controller 6 as well as incoming signals can be stored, and a processing unit 12, with which, among other things, incoming signals and data stored in the memory 11 can be processed. The crane controller 6 can also comprise a display 16. A communication of the crane controller 6 with the display 16 can be wired and/or wireless. In the embodiment shown in Figure 6a, the sensor system for detecting the geometry of the crane 1 comprises an angle-of-rotation sensor f1 for detecting the angle of rotation f1 of the crane column 2, an articulation-angle sensor k1 for detecting the articulation angle a1 of the main arm 3 relative to the crane column 2, an articulation-angle sensor k2 for detecting the articulation angle b1 of the articulated arm 4 relative to the main arm 3 as well as a extension-position sensor s1 for detecting the extension position x1 of the extension arm 5.

Analogously to Figure 6a, an embodiment of the crane 1 according to Figures 1b and 2b is shown in Figure 6b. The configuration of the crane 1, as shown, comprises a second articulated arm 7 arranged on the extension arm 5 of the articulated arm 4. As an additional

sensor system for detecting the operating parameters of the crane 1, an articulation-angle sensor k3 for detecting the articulation angle g_1 of the second articulated arm 7 relative to the articulated arm 5 and a extension-position sensor s2 for detecting the extension position x_2 of the second extension arm 8 are provided.

- 5 An analogous embodiment of the arrangement shown in Figures 6a and 6b consisting of a crane 1 according to Figures 1c and 2c and a crane controller 6 is equally conceivable.

Figure 7 shows by way of example a display 16 of the crane controller 6 of a proposed crane 1. The display 16 can serve purely for display, but can also be formed as a touch display and thus simultaneously represent a menu-driven user interface of the crane controller 6. Different operating modes of the crane controller 6 can be selected via
10 operating mode functions 26a, 26b, 26c that can be chosen by a user. Thus, in this example, a working position operating mode, in which the crane geometry of the crane 1 is brought into a working position in a predetermined sequence of movements, can be selected via a first operating mode function 26a that can be chosen. A parking position
15 operating mode, in which the crane geometry of the crane 1 is brought into a parking position in a predetermined sequence of movements, can be selected via a second operating mode function 26b that can be chosen. The coordinate control operating mode, in which the crane controller 6 is configured to carry out a coordinate control of the arm system, can be selected via a third operating mode function 26c that can be chosen. When
20 the operating mode function 26c is selected, a safety query to be confirmed by a user, as represented in Figure 14, can optionally be effected. Settings of the coordinate control operating mode (for example configuration and/or ranking of operating profiles, specifications for different degrees of freedom, etc.) can be altered via the fourth operating mode function 26d that can be chosen.

25 Figures 8a, 8b and 8c show by way of example embodiments of user interfaces, which are in each case formed by displays 16 of crane controllers 6, which can be formed as touch displays. The functions 27a, 27b, 27c, 27d, 27e, 27f, 27g, 27h, 27i, 27j, 27k represented here that can be chosen by a user are used in each case for the selection of an operating profile of the crane controller 6 linked to the respective function 27a, 27b, 27c, 27d, 27e,
30 27f, 27g, 27h, 27i, 27j, 27k in the coordinate control operating mode. In each of the operating profiles that can be selected, at least two arm selections in the form of a subset of

the arms 2, 3, 4, 5, 7, 8, 18 of the arm system of the crane 1 are stored in a predefined or predefinable ranking from a higher prioritization to a lower prioritization or are continuously determined during operation. The crane controller 6 is formed to use and actuate the arm selections stored in the selected operating profile according to their prioritization for carrying out the coordinate control of the arm system.

The function 27a, 27d and 27h respectively selected in Figures 8a to 8c is marked on the display 16 by a black dot (filled circle), with the result that the user immediately sees which operating profile is selected. The crane represented in the pictograms of Figures 8a and 8b can be based on an embodiment of a crane 1 according to Figures 1a and 2a, respectively, and the crane represented in Figure 8c can be based on an embodiment of a crane 1 according to Figures 1b and 2b, respectively. The same is conceivable for an embodiment of a crane 1 according to Figures 1c and 2c, respectively.

The menus shown in Figures 8a to 8c can for example correspond in each case to a submenu, which can be reached by selecting the function 26d in the menu of Figure 7.

With the functions 27a, 27b and 27c shown in Figure 8a, an arm system of a crane 1 can be held in a preferred arm position in a coordinate control operating mode. A selection of the function 27a can for example correspond to a default configuration of the crane 1, in which the arm system is held in an arm position that is optimized in terms of utilization and range. More precise details regarding this are to be found in Figure 9a.

A selection of the function 27b can for example correspond to a configuration of the crane 1 in which the arm system is held in an arm position which is ideally suitable for transporting bulky loads. Details regarding this are to be found in Figure 9b.

A selection of the function 27c can for example correspond to a configuration of the crane 1 in which specifically the main arm 3 of the arm system is held in a preferred position. Details regarding this are to be found in Figure 9c.

A selection of the functions 27d to 27g in Figure 8b can bring about a use of an arm selection in the form of a subset (3, 4, 5; 4, 5; 3, 5; 3, 4) of the set of the arms (3, 4, 5) of the arm system when the coordinate control of the arm system of a crane 1 is carried out

according to Figure 1a or 2a. A selection of the function 27d can correspond to an arm selection in which, when the coordinate control is carried out, the main arm 3 and the articulated arm 4, the articulated arm 4 and the extension arm 5, or the main arm 3 and extension arm 5 are used depending on the suitability or prioritization. A selection of the
5 function 27e can correspond to an arm selection in which, when the coordinate control is carried out, the articulated arm 4 and the extension arm 5 are used. A selection of the function 27f can correspond to an arm selection in which, when the coordinate control is carried out, the main arm 3 and the extension arm 5 are used. A selection of the function 27g can correspond to an arm selection in which, when the coordinate control is carried out,
10 the main arm 3 and the articulated arm 4 are used. A selection of the respective functions limit the remaining degrees of freedom of the movement of the arms of the arm system.

Analogously thereto, for a selection of the functions 27h to 27k in Figure 8c, when the coordinate control of the arm system of a crane 1 is carried out according to Figure 1b or 2b, an arm selection of a corresponding subset of the set of the arms (3, 4, 5, 7, 8) of the arm
15 system can be used.

Figures 9a to 9c show possible application examples which make use of operating profiles.

In the example of Figure 9a, for the degree of freedom α of the pivoting movement of the main arm 3, a target angle α_0 is set which is located in an angle range which is optimized in terms of utilization and range (e.g. 20°), for example by a corresponding function of the user
20 interface having been selected for setting the target angle α_0 of the degree of freedom α of the pivoting movement of the main arm 3.

Thus, the crane 1 substantially achieves the maximum lifting force and the maximum range. If possible, an arm selection which comprises articulated arm 4 and extension arm 5 is always proceeded with in this application example.

25 In the example of Figure 9b, in relation to the articulated arm 4, it is established that the articulated arm 4 always stops at a settable value W_K before 180° to prevent a complete extension (180°) thereof, for example by a corresponding function of the user interface having been selected for restricting the degree of freedom β of the pivoting movement of the articulated arm 4 to a partial range $\beta_1 - \beta_4 < \beta_2$ (cf. also Figure 3b regarding this; $\beta_4 =$

180° - W_K). Such a configuration is ideal for transporting bulky loads. If possible, an arm selection which comprises main arm 3 and extension arm 5 is always proceeded with in a prioritized manner in this application example.

In the example of Figure 9c, the main arm 3 is held in its target position (e.g. $> 60^\circ$) for as long as possible. This amounts to an at least temporary limitation of the degree of freedom α of the pivoting movement of the main arm 3 to a partial range $\alpha_3 - \alpha_2$ (see also Figure 3a regarding this). If the main arm 3 departs from its target position downwards (in the direction 0°), it is always positioned back at its target angle again, if or as soon as the movement allows it. A permanent lowering of the main arm 3 during working in the steep position can thus be prevented. This reset function of the main arm 3 can be achieved for example using the arm selections of the operating profile according to Table 4, in which the arm selection with the prioritization 1 (articulated arm 4 and extension arm 5) is always proceeded with if possible. The crane 1 is moved for example in a coordinate-controlled manner using the arm selections of the operating profile according to Table 4 and, in the course of the movement of the arm system, the main arm 3 departs from its target position and is at an angular position of 50° . Subsequently, owing to a limit of travel or a re-start of the movement, a change of the arm selection occurs. After that, the two arm selections which comprise the main arm 3 (thus the arm selection with the prioritization 2 and the arm selection with the prioritization 3) are evaluated by the crane controller 6 as to whether the target position of the main arm 3 can be arrived at again with the current user specification. Thereafter, the arm selection which moves the main arm 3 back into its target position the quickest is temporarily (dynamically) put in first place (or obtains the prioritization with the number 1). When the target position of the main arm 3 is reached, the arm selection temporarily put in first place is put back to its original position according to Table 4 (or obtains its original prioritization again).

Figures 10a to 10e show by way of example embodiments of user interfaces which are in each case formed by displays 16 of crane controllers 6, which can be formed as touch displays.

If the display 16 of the crane controller 6 is implemented as a touch display, then the user interface can be implemented directly via the touch display. For example, by touching a crane arm 2, 3, 4, 5, 7, 8, represented on the display 16 once, the corresponding degree of

freedom can be limited. To visualize the limitation the colour of the correspondingly limited crane arm 2, 3, 4, 5, 7, 8 can change from white to black. If the crane arm 2, 3, 4, 5, 7, 8 is touched a further time, the limitation can be nullified again and the representation of the crane arm 2, 3, 4, 5, 7, 8 changes from black to white. An embodiment of the user interface as represented in Figures 10a to 10e is advantageous in particular in the case of an embodiment of the user interface via the touch display.

If this display 16 is not implemented as a touch display or the like, the menu-driven user interface can be navigated via an operating element. In such an embodiment of the user interface, an embodiment as shown in Figures 8a to 8c is advantageous. In such a case, an embodiment as represented in Figures 10a to 10e can for example act as a type of status display for the user, who can thus recognize at a glance which crane arms 2, 3, 4, 5, 7, 8 or degrees of freedom are limited.

The represented functions 27l, 27m, 27n, 27o, 27p, 27q of the crane controller 6 that can be chosen by a user, in the coordinate control operating mode, serve in each case for selecting an arm of the arm system of the crane 1 the degree of freedom of which is to be limited by being set to a predefined or predefinable value (or partial range). In other words, through the functions 27l, 27m, 27n, 27o, 27p, 27q that can be chosen by a user, it is possible to select which arms of the arm system are to be blocked, wherein the blocked arms no longer participate in the coordinate-controlled movement of the arm system and, instead, remain in their blocked position. Regarding this, an arm system of a crane 1, which comprises a crane column 2, a main arm 3, an articulated arm 4 and a extension arm 5, similarly to the embodiment of Figures 1a and 2a, is illustrated in each case graphically on the displays 16 of Figures 10a and 10b. The arm systems of the cranes 1 represented on the displays 16 of Figures 10c to 10e additionally comprise a second articulated arm 7 and a second extension arm 8. The arms blocked in each case via the functions 27l, 27m, 27n, 27o, 27p, 27q that can be chosen by a user are represented in each case in black in the illustrations of the arm systems.

Figures 11a to 11c show by way of example embodiments of user interfaces which are formed in each case by displays 16 of crane controllers 6, which can be formed as touch displays. The functions 27r, 27s, 27t, 27u, 27v, 27w, 27x, 27y, 27z represented here that can be chosen by a user serve in each case for inputting information about an additional

device attached to the arm system of the crane 1. Via the functions 27r and 27s represented in Figure 11a that can be chosen, for example a menu is reached via which information about an additional device in the form of an arm extension 10 or an implement 9 (see Figures 5a and 5b) can be selected from a database stored in the memory 11 of the crane controller 6. Via the function 27t represented in Figure 11a that can be chosen, for example a setup screen can be reached via which information about additional devices not stored in the memory 11 of the crane controller 6 can be input. Via the functions 27u, 27v, 27w, 27x represented in Figure 11b that can be chosen, an angular position (angle ϑ) of an additional device attached to the arm system in the form of an arm extension 10 (see Figure 5b) can be selected or input. The functions 27y, 27z represented in Figure 11c that can be chosen serve for selecting the setup state of an additional device attached to the arm system in the form for example of one or more manually actuatable push-out extensions.

Figure 11d shows an embodiment of an input screen 13, displayed on a display 16, via which information about the function range and/or dimension data and/or angular positions for the at least one additional device 9, 10 can be selected or input and can be transferred to the crane controller 6.

Figure 12 shows by way of example the limitation of the degree of freedom β of the articulated arm 4 to a partial range $\beta_1 < \beta_3 - \beta_2$, in order to make a so-called overextension of the articulated arm 4 possible, by the crane controller 6, in the coordinate control operating mode, providing an assistance function which can be selected via a function of the user interface that can be chosen by the user.

An imaginary extension of the main arm 3 (main arm line) and an imaginary line running perpendicularly thereto through the pivot bearing of the articulated arm 4 on the main arm 3 (pivot bearing line) form four regions or quadrants. Quadrant 1 denotes the region between the main arm line and the pivot bearing line above the main arm line and in the direction of the imaginary extension of the main arm 3. Quadrant 2 denotes the region between the main arm line and the pivot bearing line above the main arm line and in the direction of the main arm 3. Quadrant 3 denotes the region between the main arm line and the pivot bearing line underneath the main arm line and in the direction of the main arm 3. Quadrant 4 denotes the region between the main arm line and the pivot bearing line underneath the main arm line and in the direction of the imaginary extension of the main arm 3.

In the left-hand image, the articulated arm 4 is located in quadrant 4. When the articulated arm 4 approaches the dead centre (the articulated arm angle is 180° , i.e. the articulated arm 4 is arranged in an exactly straight extension relative to the main arm 3) starting from quadrant 4, the articulated arm 4 is moved into the quadrant 1 and the degree of freedom β of the articulated arm 4 is restricted to quadrant 1 (see the right-hand image).

As soon as the articulated arm 4 is located in quadrant 1, it will move only in this quadrant, in order to keep the calculation in the coordinate control operating mode unambiguous.

Figure 13a shows the display 16 of a crane controller 6 of a proposed crane 1. The representation on the display 16 of the crane controller 6 can correspond to a representation in the operating mode, in which a free control of the arm system of the crane 1 on the basis of control commands input by the user is possible. The representation shown in Figure 13a contains graphic representations of several linear levers 30 for the visualization of the function assignments that apply in this operating mode.

Figure 13b shows an embodiment of a control panel 15 of the crane controller 6. In the embodiment represented, the control panel 15 has at least one display 16 and operating elements 17 in the form of a knob 29, a linear lever 30 and a push button 31. The operating elements can serve for navigating the menu-supported user interface, for selecting the function that can be chosen by a user or for issuing control commands by a user.

In an embodiment of the control panel 15 according to the embodiment of the crane controller 6 according to Figure 13a, the control panel 15 can have a predefined operating element 17 for example in the form of a push button 31 configured as a dead man's switch. If the crane controller 6 is in the coordinate control operating mode, it is possible to switch to the further operating mode by actuation of the operating element 17 in the form of the push button 31 configured in such a way. This switch to the further operating mode lasts as long as the operating element 17 in the form for example of the push button 31 remains actuated by the user.

The display 16 represented in Figure 13a can for example be displayed if, in the coordinate control operating mode, the above-described dead man's switch is pressed, wherein the crane controller switches to the further – freely controllable – operating mode. This has

been made apparent to the operator with reference to the representation on the display 16. This can be effected independently of the embodiment variant of the display 16 (whether touch display or not).

Figure 14 shows a display 16 with a safety query represented thereon, which is to be confirmed for example by a user, if the latter switches to the coordinate control operating mode. As represented in Figure 7, this safety query can be effected when the operating mode function 26c is selected for changing to the coordinate disruption operating mode.

List of reference numbers:

	1	crane
	2	crane column
	3	main arm
5	4	articulated arm
	5	extension arm
	6	crane controller
	7	second articulated arm
	8	second extension arm
10	9	implement
	10	arm extension
	11	memory
	12	processor
	13	setup screen
15	14	crane tip
	15	control panel
	16	display
	17	operating element
	18	main arm extension arm
20	19	vehicle
	20	slewing gear
	21	main cylinder
	22, 23, 25	articulated cylinder
	24	further articulated arm
25	26a – 26d	operating mode functions that can be chosen
	27a – 27z	functions that can be chosen
	28	connecting region
	29	knob
	30	linear lever
30	31	push button
	V1, h1, h2, h3	axes
	α , β , φ , γ , L, J, H	arm system degrees of freedom
	φ_0 , φ_1 , φ_2 , φ_3 , φ_4	crane column pivoting angles

	$\alpha_0, \alpha_1, \alpha_2, \alpha_3, \alpha_4$	main arm pivoting angles
	$\beta_0, \beta_1, \beta_2, \beta_3, \beta_4$	articulated arm pivoting angles
	$\gamma_0, \gamma_1, \gamma_2, \gamma_1, \gamma_4$	second articulated arm pivoting angles
	L_0, L_1, L_2, L_3, L_4	extension arm extension positions
5	J_0, J_1, J_2, J_3, J_4	second extension arm extension positions
	H_0, H_1, H_2, H_3, H_4	main arm extension arm extension positions
	ϑ	arm extension angle
	a_1, b_1, g_1, d_1	angle
	x_1, x_2	extension position
10	s_1, s_2	extension-position sensor
	k_1, k_2, k_3	articulation-angle sensor
	f_1	angle-of-rotation sensor

Claims

1. Crane (1), in particular loading crane, with an arm system that has several arms, wherein the arm system has at least:

- 5 - a crane column (2), rotatable about an axis of rotation, which is mounted pivotable over a structurally predefined crane column pivoting range ($\varphi_1 - \varphi_2$) and has one degree of freedom (φ) due to its pivotable mounting,
- a main arm (3), which is mounted on the crane column (2) pivotable over a structurally predefined main arm pivoting range ($\alpha_1 - \alpha_2$) and has one degree of freedom (α) due to its pivotable mounting,
- 10 - an articulated arm (4), which is mounted on the main arm (3) pivotable over a structurally predefined articulated arm pivoting range ($\beta_1 - \beta_2$) and has one degree of freedom (β) due to its pivotable mounting,
- at least one extension arm (5), which is mounted in the articulated arm (4) displaceable over a structurally predefined extension range ($L_1 - L_2$) and has
15 one degree of freedom (L) due to its displaceable mounting,

and wherein the crane (1) has a crane controller (6) which is configured, in a coordinate control operating mode, to carry out a coordinate control of the arm system,

20 characterized in that the crane controller (6) has a user interface, wherein the user interface has at least one function that can be chosen by a user, through which at least one of the degrees of freedom (α , β , φ , L) of the arm system is limitable or limited in the coordinate control operating mode.

2. Crane according to claim 1, wherein the arm system additionally has a second articulated arm (7), which is mounted on the extension arm (5) pivotable over a
25 structurally predefined second articulated arm pivoting range ($\gamma_1 - \gamma_2$) and has one degree of freedom (γ) due to its pivotable mounting, and which preferably comprises at least one second extension arm (8), which is mounted in the second articulated arm (7) displaceable over a structurally predefined second extension arm extension range ($J_1 - J_2$) and has one degree of freedom (J) due to its
30 displaceable mounting, wherein at least one of the degrees of freedom (α , β , φ , γ , L , J) of the arm system is limitable or limited through the at least one function that can

be chosen by the user.

3. Crane according to claim 1 or 2, wherein the arm system additionally has at least one main arm extension arm (18), which is mounted in the main arm (3) displaceable over a structurally predefined extension range ($H_1 - H_2$) and has one
5 degree of freedom (H) due to its displaceable mounting, wherein at least one of the degrees of freedom ($\alpha, \beta, \phi, \gamma, L, J, H$) of the arm system is limitable or limited through the at least one function that can be chosen by the user.
4. Crane according to one of claims 1 to 3, wherein at least one additional device (9,
10) in the form of an implement (9) and/or an arm extension (10), preferably an arm extension (10) that is static and can optionally be arranged at a predefinable angle (ϑ), is arranged on the arm system.
5. Crane according to claim 4, wherein information, preferably information about the
15 function range and/or dimension data and/or angular positions, for the at least one additional device (9, 10) can be transferred to the crane controller (6) via the user interface, wherein the information can be selected from a database stored in a memory (11) of the crane controller (6) and/or can be input via the user interface, preferably via a setup screen (13).
6. Crane according to one of the preceding claims, wherein the crane controller (6) is
20 configured to carry out a coordinate control of the crane tip (14) or a predefined or predefinable point of the arm system or a predefined or predefinable point supported by the arm system.
7. Crane according to one of the preceding claims, wherein at least one degree of
25 freedom ($\alpha, \beta, \phi, \gamma, L, J, H$) of the arm system is limitable or limited through the at least one function that can be chosen by the user, in order to nullify or reduce an overdetermination of the arm system.
8. Crane according to the preceding claim, wherein the degree of freedom (ϕ) of the
rotatable crane column (2) is excluded from the quantity of limitable or limited
degrees of freedom ($\alpha, \beta, \gamma, L, J, H$) to retain the pivotability of the crane column (2).

9. Crane according to one of the two preceding claims, wherein, through the at least one function that can be chosen by the user, one degree of freedom (α , β , φ , γ , L , J , H) of the arm system is limitable or limited or all degrees of freedom (α , β , φ , γ , L , J , H) of the arm system except for two degrees of freedom are limitable or limited.

5 10. Crane according to one of claims 7 to 9, wherein the crane controller (6) is configured, in the coordinate control operating mode, to use an arm selection in the form of a subset of the arms (2, 3, 4, 5, 7, 8, 18) of the arm system to carry out the coordinate control of the arm system, wherein the crane controller (6) has at least one operating profile, in which at least two arm selections are stored in a predefined or predefinable ranking from a higher prioritization to a lower prioritization or are
10 determined continuously, and the crane controller (6) is configured to use and actuate the arm selections stored in the at least one operating profile according to their prioritization for carrying out the coordinate control of the arm system, wherein the at least one operating profile can be selected through the at least one function
15 that can be chosen by the user.

11. Crane controller according to the preceding claim, wherein the crane controller (6) is configured to use an arm selection for the coordinate control depending on a predefinable and/or a predefined and/or a prevailing position of the arm system.

20 12. Crane according to one of the two preceding claims, wherein the crane controller (6) is configured in order that the use and actuation of an arm selection from the at least two arm selections is additionally effected depending on the ability of the coordinate control to be carried out with the respective arm selection.

13. Crane according to one of the preceding claims, wherein the limitation of the at least one degree of freedom (α , β , φ , γ , L , J , H) is effected in that it
25 - is settable or set to a predefined or predefinable value (α_0 , β_0 , φ_0 , γ_0 , L_0 , J_0 , H_0) and/or
- is restrictable or restricted to a predefinable or predefined partial range ($\alpha_1 < \alpha_3$ – $\alpha_4 < \alpha_2$; $\beta_1 < \beta_3$ – $\beta_4 < \beta_2$; $\varphi_1 < \varphi_3$ – $\varphi_4 < \varphi_2$; $\gamma_1 < \gamma_3$ – $\gamma_4 < \gamma_2$; $L_1 < L_3$ – $L_4 < L_2$; $J_1 < J_3$ – $J_4 < J_2$; $H_1 < H_3$ – $H_4 < H_2$) and/or
30 - is restrictable or restricted in relation to its rate of change (α , β , φ , γ , L , J , H).

14. Crane according to the preceding claim, wherein, through a limitation of the at least one degree of freedom (α , β , φ , γ , L , J , H), the degree of freedom (β) of the articulated arm (4) is restrictable or restricted to a predefinable or predefined partial range ($\beta_1 < \beta_3 - \beta_4 < \beta_2$), preferably to a predefinable or predefined quadrant, with the result that, in the coordinate control operating mode, the articulated arm (4) is positionable or positioned in an overstretched pivot position above an imaginary extension of the main arm (3).
15. Crane according to one of the two preceding claims, wherein the predefinable or predefined partial range ($\alpha_1 < \alpha_3 - \alpha_4 < \alpha_2$; $\beta_1 < \beta_3 - \beta_4 < \beta_2$; $\varphi_1 < \varphi_3 - \varphi_4 < \varphi_2$; $\gamma_1 < \gamma_3 - \gamma_4 < \gamma_2$; $L_1 < L_3 - L_4 < L_2$; $J_1 < J_3 - J_4 < J_2$; $H_1 < H_3 - H_4 < H_2$) is smaller than or equal to 2° , preferably smaller than or equal to 0.5° , or is smaller than or equal to 10 cm, preferably smaller than or equal to 2.5 cm, and/or the rate of change (α , β , φ , γ , L , J , H) is smaller than or equal to 0.2° per second, preferably smaller than or equal to 0.05° per second, or is smaller than or equal to 2 cm per second, preferably smaller than or equal to 0.5 cm per second.
16. Crane according to one of the preceding claims, wherein the crane controller (6) has a, preferably portable, control panel (15) and the user interface is formed on the control panel (15).
17. Crane according to one of the preceding claims, wherein the user interface is menu-driven and/or comprises at least one operating element (17) of the crane controller (6).
18. Crane according to one of the preceding claims, wherein the user interface comprises at least one operating element (17) of the crane controller (6) and a selection of the function that can be chosen is effected through an actuation of the at least one operating element (17) by a user.
19. Crane according to the preceding claim, wherein the crane controller (6) is configured, in a further operating mode, to carry out a free control of the arm system, wherein a free actuation of the arm system is effected in the further operating mode through the at least one operating element (17), wherein in each

case one operating element (17) is provided for the input of control commands for moving in each case one arm of the arm system along one degree of freedom (α , β , φ , γ , L, J, H), wherein the degree of freedom (α , β , φ , γ , L, J, H) of the arm system assigned to the operating element (17) in the further operating mode is limitable or limited through an actuation of the at least one operating element (17) by a user in the coordinate control operating mode.

20. Crane according to one of the preceding claims, wherein the crane controller (6) is configured, in a further operating mode, to carry out a free control of the arm system on the basis of control commands input by a user, wherein, starting from the coordinate control operating mode, a switch to the further operating mode is effected for as long as a predefinable or predefined operating element (17) of the crane controller (6), preferably a dead man's switch of the crane controller (6), remains actuated by a user.

21. Vehicle (19) with a crane (1) according to one of the preceding claims.