

MOORING DEVICE AND MOORING SYSTEM

The invention relates to a mooring device for mooring a ship, in particular an automatic mooring device, for mooring a ship. Even more in particular, the invention relates to a mooring device for mooring a ship, the mooring device having a moored state, in which it engages the ship, and a non-moored state in which it does not engage the ship, the mooring device comprising a base, a movable arm, fixed with respect to the base with a first end, a second, opposite end of the arm being movable with respect to the base between a retracted position, in which the second end is relatively close to the first end and an extended position, in which the second end is relatively far from the first end, a connector carried by the arm, the connector having an engaged state, in which it engages an object for mooring, such as the hull of a ship, and a disengaged state, in which it does not engage the object, a winch, a tensile element having a first end engaged by the winch and a second, opposite end fixed with respect to the second end of the arm and/or the connector, and a distance keeping system configured for keeping a minimum and non-zero distance between the base and the object engaged by the connector.

Such a mooring device is known, for instance from “A ship-to-ship automatic docking system for ocean cargo transfer” by Kim et al. (J Mar Sci Technol (2014) 19:360-375, DOI 10.1007/s00773-014-0256-3). Kim et al. propose a device (see figure 5) with a robot arm for placing a vacuum pad on a ship to be moored. After the vacuum pad has been placed, a cable, pre-connected to the vacuum pad is used to pull the ship towards the mooring device and vice versa. Contact is avoided in the traditional way, with the use of a fender. A balance of forces between the cable, which pulls the ship closer, and the fender, which maintains a minimum distance, keeps the ship in place when moored.

The device of Kim et al. has several disadvantages. For one, it is very time consuming to correctly place the fenders along a ship. Since ship-to-ship mooring may take place in a relatively rough environment, there is a desire to reduce the time needed for mooring. Indeed, any time spent during mooring causes a risk, since right before mooring is complete the ships are close to each other, but not yet safely moored. Moreover, the placement of fenders may be relatively difficult in itself.

Another disadvantage is that when mooring particular types of vessels, such as cruise ships, fenders may not be sufficiently big. This can be attributed to emergency rescue vessels, which are often suspended outboard of the cruise ship, and thus provide an obstacle for mooring. More generally, in order to safely moor when outboard objects are suspended from the ship, the distance to the ship needs to be increased, for instance to approximately 8 meters or more, which becomes prohibitively impractical using fenders.

The invention therefore has as its object to reduce at least partially at least one of the above described disadvantages.

The object is achieved using a mooring system as described above in the preamble, characterized in that the distance keeping system is integrated with the movable arm.

5 When distance is kept by the arm, fenders are no longer needed. As such, the mooring may be performed in a much shorter time, thereby increasing not only efficiency but possibly also safety. Moreover, as the arm may be made of any suitable length, a relatively large mooring distance may be achieved, such as a mooring distance of approximately minimally 8 meters, which is needed for mooring e.g. cruise ships.

10 It is noted that the invention differs vitally from the system proposed by Kim et al., which employs a robot arm only for placing the vacuum pad on the ship. The only distance keeping system proposed by Kim et al. is the fender. This can be seen from e.g. figure 5, where the arm can be extended only by slacking the line attached to the robot arm winch, which causes the arm to move outwards under the force of gravity. Needless to say, such outward movement is entirely unsuitable for
15 keeping any ship at distance, hence the required fenders.

 It is noted the distance keeping system is configured for maintaining a distance between moored ships, or a ship and e.g. the quay, in the transversal direction of the ship, i.e. athwartships. The tensile element can be used, as will be explained later, to provide forces along the beam of the ship, i.e. alongships. It is noted that the invention can also be applied without tensile element and without the
20 winch. As an example, traditional and separate tensile elements could be used in such a case.

 As another example, the winch and tensile element together could be replaced by any means of providing force in the alongships direction between the base and the connector. As a particular example of such means, reference will be made below to actuation of the arm in the alongships direction by rotation it with respect to the base around a vertical axis. Such actuation can be performed
25 by an (additional) optionally hydraulic cylinder. Throughout this application, the alongships direction is defined as the alongships direction of a ship in the moored state, which corresponds to a horizontal, sideways direction substantially perpendicular to the longitudinal direction of the arm.

 Alternatively, multiple tensile elements may be used, for instance two, which may provide a tensile force in an opposite direction alongships, i.e. one forward and the other aft.

30 Although the distance keeping mechanism is described to maintain a distance between the object for mooring, the distance keeping mechanism may alternatively be described to keep said distance between the base and the second end of the arm, or between the two opposite ends of the arm.

It is noted that depending on the environmental conditions, the forces on the moored ship may be in any direction. As such, the mooring device is preferably capable of absorbing forces in all different directions, yet it is also possible several mooring devices, for instance of different types, may be used to absorb the forces collaboratively. In any case, the mooring device as described herein is
5 capable of providing a pushing force athwartships, since said force is necessary to maintain a minimum distance to the ship.

It is further noted that a ship may be moored using the mooring device, for instance to another ship or to a quay. It is principally possible that the mooring device is placed on either one or both of the ship and or the other ship or quay. It is however envisioned that the mooring device is placed on
10 the smaller of two ships when mooring ship-to-ship, or on the quay when mooring ship-to-quay.

As an additional or alternative advantage of the mooring device described herein, the arm may be used to damp motion of the moored ship whilst it is moored. For instance, relatively small movements caused by e.g. waves may be counteracted by the arm at least to some extent. The arm may therefore be used to provide a damping force, which allows some movement of the ship within
15 predefined safety margins. In order to facilitate the damping, actuators and a controller may be provided for the arm, as will be described below, although other embodiments may exist.

In an embodiment of the mooring device, the distance keeping system comprises at least one actuator for moving the movable arm. Using the actuator, the arm may be moved, and may particularly be moved reversible and/or controllably.

20 In a particular embodiment, a such actuator may have one end fixed with respect to the base, and another, opposite end fixed with respect to the arm, said actuator being arranged for providing a pushing force between the base and the arm.

Accordingly, the actuator may be used to push the arm, or more in particular the second end thereof, away from the base and/or the first end of the arm. As such, the arm can be used, by virtue of
25 said actuator, to maintain the athwartships minimum distance.

It is noted that in some cases, the arm may also provide a pulling force athwartships if needed.

Said actuator, and any other of the at least one actuator, may be an hydraulic actuator. The applicant has found that contrary to previous belief, hydraulic actuation can provide sufficient force to withstand the very large forces involved in e.g. ship-to-ship mooring.

30 The distance keeping system may further comprise a controller operatively connected to the at least one actuator for controlling the at least one actuator, wherein in the moored state, the controller is configured to control the arm by controlling the at least one actuator, in order to maintain a distance between the first and second end of the arm.

The controller is used in the moored state, to actively control the arm. The control can be based on maintaining a predefined distance between the first and second end of the arm, or between the base and the object. Of course, the predefined distance may be defined with some level of travel, i.e. as a range, defining a minimally and maximally allowed distance.

5 For this purpose, the controller may be configured to – if required – control the arm to provide a pushing force. The controller may be further configured to – in other moments – control the arm to provide a pulling force. Preferable, the controller is therefore configured to provide the pushing and pulling force selectively, as the situation requires.

10 The winch may be an automatic winch, which is optionally configured to keep a tension on the tensile element at least in the moored state.

An automatic winch is herein defined as a winch which is configured to slack or pull the tensile element in accordance with a control algorithm, for instance to keep a sufficient but limited tension on the tensile element. The winch may be configured to slack the tensile element if a tensile force on the tensile element becomes too large. The winch may be configured to pull the tensile element if it slacks.

15 The controller may further be operatively connected to the winch for controlling the winch. Accordingly, the arm and the winch can be controlled in unison, i.e. cooperatively. As such, an optimal control can be obtained. In particular, a cooperation between a pulling force provided by the winch and an partially opposite pushing force by the arm is enabled. It is noted that coordinated control of the winch and the arm may aid in preventing the use of excessive force in opposite directions.

The mooring device may comprise a position determination system operatively connected to the controller, configured for determining a position of the second end of the arm and communicating to the controller said determined position.

25 The determined position is indicative of a mutual position of the mooring device and the ship. Accordingly, the determined position can be used to effectively control the mooring device. In particular, the position may be used to monitor the mutual distance.

30 It is noted that when the mutual position of the mooring device and the ship changes, a compensation may or may not be required. Short term movements of the ship may need to be compensated for by providing an adequate force in the opposite direction. However, longer term movements need not be compensated for. As an example, if it is noted that a height difference comes to exist, for instance due to (un)loading the ship, the arm may be controlled in order to compensate minor deviations from the new mutual position instead of from the old unchanged position, thereby thus accounting for the height difference. In a situation where no account is taken of the new position,

compensation could lead to excessive use of force or even damage to the mooring device and/or the ship. Thus, monitoring the position and controlling accordingly facilitates improvement of the safety of the mooring device.

For this or another purpose, the controller may be configured to control the winch on the basis of the determined position of the arm.

It is noted that in view of existing automatic winches, this is a substantial improvement. In fact, existing automatic winches have proven to be unable to account for longer term movements, such as height differences during loading or unloading, leading to breakage of the associated tensile elements. The breakage can lead to catastrophic damage to the ship, or worse, pose a risk to personnel. Controlling the winch on the basis of a position of the arm is therefore a vital improvement which can be applied to the mooring device as described herein.

At the same time, or as an alternative, the controller may be configured to control the at least one actuator on the basis of the determined position of the arm.

The above described compensation and position-aware control may be achieved as such.

It is noted that although it is desirable to control the arm and/or winch on the basis of the position of the arm, more particularly of the second end thereof, other parameters may be used for control in addition or as an alternative. In particular, kinematic parameters such as velocity and acceleration are contemplated. Further, it is envisioned the force provided by the arm and/or the tensile element is measured by suitable sensors, and input to the controller for enhancing or enabling the control of the winch and/or the arm.

The tensile element may be led to an engaging position fixed with respect to the base at a distance from the arm.

Accordingly, the arm may be used to supply an athwartships force, whereas the tensile element may provide a force with an alongships component. For this purpose, the tensile element may extend substantially alongships, such as at an obtuse and non-zero angle with respect to longitudinal direction of the ship, i.e. away from the mooring device along the quay or ship upon which the mooring device is placed.

In order to provide the tensile force in the alongship direction, the engaging position may be positioned at a distance from the arm in the alongship direction, i.e. further down the quay or further down the longitudinal direction of the ship.

The engaging position may be provided by an engaging element, which may be placed at a distance from the arm. The engaging element may be connected, directly or indirectly, to the base.

Although it is possible to provide a movable engaging element, it is envisioned that both the base and the engaging element are fixed with respect to their environment, and thus with respect to each other.

The engaging element may comprise a pulley arranged at the engaging position.

5 The pulley may allow leading the tensile element to a desired engaging position, whilst the winch can be placed elsewhere, thereby allowing a compact construction of the mooring device and/or facilitating control of the winch more easily.

In particular, the winch may be arranged closer to the arm than the engaging position, thereby allowing relatively easy connection of the winch to the controller, which at the same time may control the arm. In particular, the controller, whether it controls the arm or not, may be arranged in a housing
10 arranged at the first end of the arm. The winch may be arranged without said same housing, whilst the pulley, or some other engaging element, is placed at a distance.

The connector may comprise a latching element for latching onto a surface in the engaged state, for example a vacuum pad or a magnetic mooring pad.

Using a latching element, a connection may be made between the ship to be moored at a
15 desirable position, without the need of e.g. a bitt. In particular, the connection may be made with a surface of the ship, such as the outer surface of the hull. Suitable latching elements may be formed by employing e.g. a vacuum pad, or a magnetic mooring pad.

The latching element may be controllable in order to provide a latching force in accordance with a control signal, for instance transmitted from the controller.

20 The arm of the mooring device may be rotatable with respect to the base around two mutually perpendicular axes which are both perpendicular to a local axis of the arm at its first end.

The first of said mutually perpendicular axes runs substantially alongships. The second of the mutually perpendicular axes runs substantially vertically.

Thus, in this embodiment the arm may be titled up and down, thereby rotating around the
25 alongships axis, and may be swept from side to side, thereby rotating around the vertical axis. As a result, the arm may be used to move the connecting element in the vertical alongships plane. Movement of the arm in said plane may facilitate allowing some mutual movement of the ship and the mooring device and/or for bringing the connection element to a suitable position on the ship and/or for moving the connection element to different positions on the ship while mooring. The latter will be
30 explained in more detail below.

In particular, it is useful if the distance keeping system comprises actuators configured for actuating rotation of the arm around said two mutually perpendicular axes, wherein optionally the actuators are operatively connected to the controller.

Accordingly, the connector may be used to move the arm in the vertical alongships plane. This may be particularly useful for moving the connecting element to a suitable position when mooring a ship. When the ship is moored, the movement of the arm may be used to allow some movement of the ship, but to restrict large movements.

5 Moreover, an actuator for rotation around the vertical axis, i.e. sweeping the arm substantially sideways/horizontally, can be used to compliment or replace a winch and tensile element construction, for limiting movement in the alongships direction when moored. This advantage can be achieved if the arm is actuated in its rotation around the vertical axis, and does not require rotation about the alongships axis, nor does it require actuation around the alongships action. Actuation for rotation
10 around the vertical axis is an example of a means for providing force in the alongships direction.

The arm is actuated in a sweeping manner to counteract alongships movements, and the winch and tensile element are dispensed with, an especially compact construction can be achieved, which may optimize the use of space around the base of the mooring device.

15 Actuation of rotation of the arm around the vertical axis can be achieved by a e.g. a hydraulic (or alternatively pneumatic) cylinder arranged between the base and the connector. Joints, particularly allowing at least rotation around the vertical axis, are preferably arranged on both sides of the cylinder. Alternative means of mounting the cylinder are also possible.

20 To enhance transfer of the forces by the cylinder, a first end of the cylinder, near the base may be mounted to the base at a position offset a first distance sideways (i.e. horizontally away, perpendicular to the longitudinal direction of the arm, corresponding to the alongships direction). The first distance may be at least several times the width of the arm in the same direction.

25 Alternatively or additionally, a second end of the cylinder, near the connector, may be mounted to the connector at a position offset a second distance sideways. The second distance may be smaller than the first distance. The second distance may be at least as large as the width of the arm in the same direction. For this purpose, a mounting frame may be provided on a side of the arm, which carries a joint to which the cylinder is connected.

30 An additional advantage enabled for the first time by the mooring device described herein, is that the arm may be used in conjunction with additional mooring devices, to move the connecting element to different positions on the ship. The ship can be moored using one mooring device whilst the other is moved. As such, relatively large movements of the ship may be allowed, and even caused, whilst the ship is moored.

A particularly important use-case for this movement is aligning a ship after mooring, i.e. whilst remaining moored. Accordingly, the alignment need not be performed before the ship is moored, so that time is saved and risks are reduced.

5 The arm may be extendable and retractable, i.e. its length may be increased or reduced by extending and retracting. The arm may be telescopic for this purpose. The extension and retraction may be powered hydraulically or in another way. Suitable (hydraulic) actuator(s) may be provided, optionally operatively connected to the controller.

10 The invention also relates to a mooring system which comprises at least two mooring devices according to any of the preceding claims, the bases of which are fixed with respect to each other, or which share a base.

An advantage of such a mooring system is that tensile elements of the at least two mooring devices may be able to provide substantially opposing forces in the alongships direction, whilst the arms supply the athwartships forces. Accordingly, such a mooring system is able to provide forces in all necessary directions.

15 To facilitate the desired directionality, the tensile elements of the at least two mooring systems are led to engaging positions on opposite sides of the arms.

As an alternative advantage of the mooring system described herein, the arms may be used in conjunction to “walk” along the moored ship. Accordingly, the ship may be moved with respect to the mooring devices, more specifically to the bases thereof, whilst being safely moored.

20 To facility cooperation of the at least two mooring devices, they may be operatively connected for being controlled cooperatively. The cooperative control may be provided so as to let the arms walk along the ship to be moored, so that the ship can be moved whilst being safely moored.

For this purpose at least the arms of the mooring devices may be controlled cooperatively, although it is also possible to coordinate control of the winches with each other and/or with the arms.

25 Although the bases are fixed with respect to each other in use of the mooring devices, it is principally possible to move the bases with respect to each other during other times.

The invention will be further elucidated with reference to the attached figures, in which: Figures 1 – 4 show schematically different perspective views of two ships moored using multiple mooring devices as described herein. Figure 5 shows schematically another embodiment of such a mooring device.

In all figures, like elements are referred to using like reference numerals.

The figures show a larger, first ship 1 and a smaller, second ship 2. The ships 1, 2 are shown partially in order to allow showing more details of mooring devices 3 which are used to perform ship-to-ship mooring of the ships 1, 2. The mooring devices 3 can be used alternatively to moor a ship 1 to a quay. The larger ship 1 shown as an example herein, is a cruise ship 1. The cruise ship 1 has an emergency raft suspended outboard in a casing 4. Accordingly, the ship 2 which is moored to the cruise ship 1 for instance for supplying goods or fuel to the cruise ship 1, may need to be moored at a relatively large distance from the cruise ship 1, in order to prevent contact with the outboard suspended raft in its casing 4. Of course, mooring with a relatively large distance, or with the mooring devices 3 as described herein, may be required or desired in other situations as well.

Details of the mooring devices 3 will be described with reference to figure 3 in particular, in which reference numerals are provided, however the details may be visible in other figures as well. Each mooring device 3 has a base 5, and a movable arm 6 which extends from it. In this case, the movable arm 6 is telescopic, and can therefore be extended or retracted. The movable arm 6 has a first end 6A which is arranged on a rotary joint 7, so that the arm 6 can rotate with respect to the base about a vertical axis. The vertical axis is substantially parallel to the view axis of figure 3, and substantially perpendicular to an alongships axis AL and an athwartships axis AT. Rotation of the arm 6 in the rotary joint 7 is driven by an actuator (not shown), which is connected to the below-described controller. The rotary joint 7 carries a hinge 8 which holds the first end 6A of the arm 6. The hinge 8 is arranged so that the arm 6 can pivot up and down, i.e. the arm 6 can rotate around the alongships axis AL. The pivoting motion about the hinge 8 is powered by an hydraulic actuator 9, which extends from the hinge 8 to the arm 6 approximately halfway along the arm 6. Since the hinge 8 is arranged in a fixed location with respect to the base 5, the actuator 9 can provide a pushing force, and in this case also a pulling force, between the base 5 and the arm 6, in order to move the arm 6. The hydraulic actuator 9 is powered by a hydraulic pump (not shown) arranged in a housing 10. The housing 10 also includes a controller which controls the hydraulic system for controlling the actuator 9 to move the arm.

The movable arm 6 also has an opposite second end 6B. The second end 6B carries a connector 11, which as an example for the purpose of the figures includes a vacuum pad 11. Using the connector 11, a physical connection capable of transferring force between the arm 6 and the ship 1 can be made. The connector 11 is engagable and disengagable, so as to allow selectively engaging the ship 1. The connector 11 is arranged on the arm 6 using a joint 12, which allows suitable rotation of the connector 11 to attach to the hull 13 of the ship 1.

Tensile elements 14 are fixed to the second end 6B of the arm 6, but may alternatively be fixed to e.g. the connector 11. In any case, the tensile elements 14 allow pulling the second end 6B of the arm 6. The mooring device 1 includes a pulley 15 which is arranged at a distance alongships from the base 5, and at a distance from the arm 6. The tensile element 14 is routed through the pulley to a winch (not shown) in the housing 10. Accordingly, the second end 6B of the arm 6 may be pulled towards the pulley, thereby providing a tensile force with an alongships AL component.

As shown in figure 3, two mooring devices 1 are arranged together on the same base 5. The winches 15 and thus the tensile elements 14 are arranged on opposite sides. The tensile elements 14 therefore provide opposing tensile forces for absorbing and/or producing alongships forces and movements, whereas the arms 6 can be used to provide athwartships forces or absorption.

The controller in the housing 10 is also connected to the hydraulic actuator 9 and to the winches. The controller controls, while the ship 1 is moored, the movement of the actuators and the winches, in order to maintain the ship 1 in a safely moored position. A position of the second end of the arm 6B is determined with the use of encoders, and fed to the controller. The controller instructs the actuator and winches accordingly, in order to push the ships 1 away if necessary and to pull it towards the mooring device 1 if necessary. Of course, alongships forces are also provided, using the winches, if necessary.

In figure 5, a similar mooring device 3 is shown. The mooring device 3 again has a base and movable arm 6 with first end 6A and second end 6B. Details of the mooring device 3 of figure 5 are equal to those of that of figures 1 – 4 in as far they are described herein, with the exception of the method of providing force in the alongships AL direction. For this purpose, the device 3 of figure 5 is provided with an actuator 16, in this case an hydraulic cylinder, connected to the controller. The cylinder engages between two rotary joints (hinges) 20 and 21. Near the base, the actuator 16 engages at a first distance d_1 , whereas it engages at a second distance d_2 near the connector 11, both distances being measured in the transversal or sideways direction, i.e. substantially horizontal and perpendicular to the longitudinal direction of the arm. The first distance d_1 is larger than the second distance d_2 . The width w of the arm 6 in the same direction is also indicated as a comparison. A mounting frame 17 is provided at the second end 6B of the arm 6 for mounting the actuator 16. Similarly, part 18 of the casing 5 forms a frame for mounting the actuator 16 to the base at the first distance d_1 from the arm. To allow up and down movement of the actuator 16 with the arm 6, additional hinge 19 is provided.

It is noted that the invention, although described with respect examples and particular embodiments, is not limited thereto. In fact, the invention is described also by the attached claims.

Claims

1. Mooring device for mooring a ship, the mooring device having a moored state, in which it engages the ship, and a non-moored state in which it does not engage the ship, the mooring device comprising:
- 5 - a base;
- a movable arm, fixed with respect to the base with a first end, a second, opposite end of the arm being movable with respect to the base between a retracted position, in which the second end is relatively close to the first end and an extended position, in which the second end is relatively far from the first end;
- 10 - a connector carried by the arm, the connector having an engaged state, in which it engages an object for mooring, such as the hull of a ship, and a disengaged state, in which it does not engage the object; and
- a distance keeping system configured for keeping a minimum and non-zero distance between the base and the object engaged by the connector;
- 15 **characterized in that**
- the distance keeping system is integrated with the movable arm.
2. Mooring device according to the previous claim, wherein the mooring device further comprises means for providing a force in an alongships direction between the base and the connector.
- 20 3. Mooring device according to the previous claim, wherein the means for providing a force in the alongships direction comprise an actuator for rotation the arm around a vertical axis.
4. Mooring device according to any of the preceding claims, wherein the mooring device, optionally
- 25 the means for providing force in the alongships direction, comprises:
- a winch;
- a tensile element having a first end engaged by the winch and a second, opposite end fixed with respect to the second end of the arm and/or the connector;
- 30 5. Mooring device according any of the preceding claims, wherein the distance keeping system comprises:
- at least one actuator for moving the movable arm.

6. Mooring device according to the previous claim, comprising a such actuator having one end fixed with respect to the base, and another, opposite end fixed with respect to the arm, said actuator being arranged for providing a pushing force between the base and the arm.
- 5 7. Mooring device according to the previous claim, wherein said actuator is an hydraulic actuator.
8. Mooring device according to any of claims 5 - 7, wherein the distance keeping system comprises:
- a controller operatively connected to the at least one actuator for controlling the at least one actuator,
- 10 wherein in the moored state, the controller is configured to control the arm by controlling the at least one actuator, in order to maintain a distance between the first and second end of the arm.
9. Mooring device according to any of the preceding claims including the winch, wherein the winch is an automatic winch, which is configured to keep a tension on the tensile element at least in the moored state.
- 15 10. Mooring device according to claims 8 and 9, wherein the controller is further operatively connected to:
- the winch for controlling the winch; and/or
 - 20 - the means for providing the alongships direction, for controlling said means.
11. Mooring device according to any of claims 8 - 10, further comprising a position determination system operatively connected to the controller, configured for determining a position of the second end of the arm and communicating to the controller said determined position.
- 25 12. Mooring device according to the previous claim, wherein the controller is configured to control the winch and/or the means for providing force in the alongships force on the basis of the determined position of the arm.
- 30 13. Mooring device according to claim 11 or 12, wherein the controller is configured to control the at least one actuator on the basis of the determined position of the arm.

14. Mooring device according to any of the preceding claims, wherein the tensile element is led to an engaging position fixed with respect to the base at a distance from the arm.
15. Mooring device according to the previous claim, further comprising a pulley at the engaging position.
16. Mooring device according to claim 14 or 15, wherein the winch is arranged closer to the arm than the engaging position.
17. Mooring device according to any of the preceding claim, wherein the connector comprises a latching element for latching onto a surface in the engaged state, for example a vacuum pad or a magnetic mooring pad.
18. Mooring device according to any of the preceding claims, wherein the arm is rotatable with respect to the base around two mutually perpendicular axes which are both perpendicular to a local axis of the arm at its first end.
19. Mooring device according to the previous claim, wherein the distance keeping system comprises actuators configured for actuating rotation of the arm around said two mutually perpendicular axes, wherein optionally the actuators are operatively connected to the controller.
20. Mooring system, comprising at least two mooring devices according to any of the preceding claims, the bases of which are fixed with respect to each other, or which share a base.
21. Mooring system according to the previous claim, wherein tensile elements of the at least two mooring systems are led to engaging positions on opposite sides of the arms.
22. Mooring system according to any of the preceding system claims, wherein the at least two mooring devices, in particular the movable arms thereof, are operatively connected for being controlled cooperatively.