

Drum suitable for anchoring a cable to a frame

TECHNICAL FIELD

The invention relates to a drum suitable for anchoring a cable to a frame and an anchoring system comprising this drum. The invention also relates to a lifting device comprising such an anchoring system and a lift machine comprising said anchoring system.

PRIOR ART

The lifting and handling of containers can be implemented using a spreader, connected by way of ropes to a crane of "Ship to Shore" (STS) type, for disembarking containers from a ship or embarking containers onto a ship. Motors mounted on the crane are used to lift or lower the spreader by way of the ropes. Fastening members (commonly known as "twist locks") are moreover attached to the spreader. The opening – or closing, respectively – of the fastening members makes it possible to attach – or release, respectively – a container. To enable their opening or closing, the fastening members are usually powered by a hydraulic unit, most commonly arranged on the spreader. The hydraulic unit can moreover be adapted to force the extension or retraction of the spreader during use, so as to adapt said spreader to the handling of containers of different sizes. The hydraulic unit is advantageously powered from the crane by way of a cable: a first end of the cable is wound around a winder mounted on the crane and a second end of the cable is connected to the spreader, advantageously by way of a frame (commonly known as a "head block") under which said spreader is mounted. Alternatively, the fastening members are entirely electrical, and their supply of power from the crane is also provided via such a cable. The cable may further comprise a databus, for example a CAN (Controller Area Network) bus, in charge of transmitting the locking or unlocking information to the fastening members along with any other item of information needed to control the crane (weighing, lighting etc.).

To avoid damaging the cable, the unwinding and winding of the cable around the winder must make it possible to keep the cable taut during all the operations of lifting, unloading, loading etc. of the containers. The unwinding and winding of the cable around the winder, so as to follow the movement of the spreader, are usually handled automatically by slaving the winder according to a theoretical model which computes the torque to be applied to the winder according to the operating phase and the position of the crane on its track.

However, since the motion of the spreader is often managed manually by the crane operator, certain movements of the spreader cannot be immediately compensated for by the winder. This is especially true in the event of sudden movements of the spreader when said

spreader is subject to impacts, for example if the container misses the hatch and strikes the guides of the container ship.

A cable anchoring system is consequently mounted on the frame under which the spreader is mounted. This anchoring system may comprise a cylindrical drum advantageously mounted rotatably with respect to the frame by way of bearings, for example ball bearings. Under the effect of the cable tension, for example in the event of a sudden movement of the spreader, said drum is set to rotate about its axis of rotation. The rotational movement of the drum incurs the winding and/or unwinding of the cable around said drum, thus allowing the cable a certain amount of travel.

The anchoring system may further comprise dampers, for example hydraulic, metallic or elastic (tensioner) dampers, and/or a compression spring suitable for damping the cable travel: particularly when the winder pulls on the cable, the compression spring supplies a return force and absorbs the impact.

However, current anchoring systems, the bulk of which is limited by the size of the frame on which they are housed, do not permit sufficient travel of the cable, particularly in the event of impacts. Specifically, the travel allowed to the cable by the anchoring system is typically in the order of 40 mm in the direction of unwinding of the cable when the winder pulls on the cable and of 40 mm in the direction of winding of the cable when the winder releases the tension on the cable. This results in rapid wear of the cable, which requires frequent and expensive maintenance operations.

BRIEF DESCRIPTION OF THE INVENTION

An aim of the invention is to design a drum suitable for anchoring a cable to a frame allowing said cable a large amount of travel while having limited bulk.

For this purpose, the invention makes provision for a drum suitable for anchoring a cable to a frame, said drum being suitable for being mounted rotatably about an axis of rotation on said frame, the drum having a lateral surface around an axis parallel to the axis of rotation, the drum being characterized in that the lateral surface comprises a first portion having at least a first bend radius measured in a plane perpendicular to the axis of rotation (referred to below by the term "plane" for brevity's sake) strictly greater than at least a second bend radius of a second portion of the lateral surface measured in said plane, the drum being suitable for allowing a travel of the cable by the winding and/or unwinding of said cable around the lateral surface along the first portion, by the rotation of said drum about the axis of rotation between a first and a second stop position.

The drum advantageously has a lateral surface of variable bend radius, the portion of said drum with a large bend radius being limited to the portion useful for the travel of the cable by winding and/or unwinding of the cable along said portion. The drum thus allows the cable a great deal of travel while having a modest bulk, making it possible to house it on small frames.

According to other optional features of the drum taken alone or in combination when this is technically possible:

- the axis of rotation intersects with the plane at an intersection point located at a distance from the center of a circle tangent to the first portion of between 0% and 10% of the value of a radius of the circle, the radius of the circle being equal to the first bend radius of the first portion, the first portion being centered around the intersection point;
- the first portion comprises the point of maximum bend radius of the lateral surface measured in the plane;
- the lateral surface has, in the plane, an ovoid shape and the first portion of the lateral surface is contained in the part of the ovoid opposite the portion of said ovoid with the smallest bend radius;
- the lateral surface has, in the plane, an ellipse shape, and the first portion of the lateral surface is contained in one of the two arcs of the ellipse delimited by the major axis of said ellipse;
- the intersection point between the plane and the axis of rotation is located on the semi-minor axis of the ellipse opposite the first portion of the lateral surface with respect to the center of the ellipse;
- the length of the first portion of the lateral surface measured in the plane is greater than 300 mm, preferably greater than 600 mm.

The invention also relates to a cable anchoring system comprising a frame, a drum as previously described mounted rotatably on the frame about the axis of rotation, and at least one spring for absorbing the forces generated by the travel of the cable between the first and the second stop position arranged between the drum and the frame.

According to other optional features of the cable anchoring system taken alone or in combination when this is technically possible:

- the at least one force absorption spring is a torsion spring or a set of two torsion springs assembled in series;
- each torsion spring comprises a first metallic and hollow square-based prism, a second metallic and hollow square-based prism housed inside the first prism with an angular offset

with respect to the first prism, and four elastomer cylinders arranged between the first prism and the second prism, in the corners of the first prism;

- the cable anchoring system comprises two torsion springs in series, the second square-based prism of the first torsion spring being connected to the second square-based prism of the second torsion spring;

- the force absorption spring is arranged along the axis of rotation so as to permit the rotation of the drum about the axis of rotation with respect to the frame between the first and the second stop position without any roller bearing or pad;

- the first and the second stop position are angularly offset with respect to the axis of rotation by an angle between 0° and 60° , preferably between 0° and 90° .

The invention also extends to a lifting device comprising:

- a spreader comprising at least one fastening member for fastening a load to be lifted,
- an anchoring system as previously described comprising a frame and a drum as previously described, the frame being attached to the spreader and the drum being attached to the frame,
- a winder suitable for being attached to a lift machine,
- a cable, a first end of the cable being anchored to the drum of the anchoring system by a fixed winding of at least two turns around the lateral surface of the drum and a second end of the cable being wound around the winder.

According to other optional features of the lifting device taken alone or in combination when this is technically possible:

- the lateral surface has a minimum bend radius in the plane strictly greater than the static bend radius of the cable;
- the winder is an electronically-controlled winder and the length of the first portion of the drum measured in the plane is equal to the double of the product of the maximum speed of the spreader by the reaction time of a control loop of said winder.

Finally, the invention extends to a lift machine, such as a crane, a gantry or a forklift truck, comprising a lifting device as previously described.

BRIEF DESCRIPTION OF THE FIGURES

Other features and advantages of the invention will become apparent from the following detailed description, with reference to the appended drawings, wherein:

- figure 1A, figure 1B and figure 1C illustrate an example of an application of a cable anchoring system according to the invention in which said system is attached to a spreader itself mounted on a crane;

- figure 2A and figure 2B show particular embodiments of the drum according to the invention in which the lateral surface of said drum respectively has, in a plane perpendicular to the axis of rotation of said drum, ovoid and ellipse shapes;

- figure 3 shows a particular embodiment of the cable anchoring system according to the invention in which the lateral surface of the drum has an ellipse shape and an axis of rotation of the drum relative to the frame at the center of the ellipse: the middle of figure 3 shows the neutral position of the drum, the bottom of figure 3 shows the scenario of the application by the cable of an under-tension on the drum driving the rotation of said drum in the direction of winding of the cable, the top of figure 3 shows the scenario of the application by the cable of an over-tension on the drum driving the rotation of said drum in the direction of unwinding of the cable;

- figure 4 shows a particular embodiment of the cable anchoring system according to the invention in which the lateral surface of the drum has an ellipse shape and an axis of rotation of the drum relative to the frame offset with respect to the center of the ellipse: the middle of figure 4 shows the neutral position of the drum, the top of figure 4 shows the scenario of the application by the cable of an under-tension on the drum driving the rotation of said drum in the direction of winding of the cable, the bottom of figure 4 shows the scenario of the application by the cable of an over-tension on the drum driving the rotation of said drum in the direction of unwinding of the cable;

- figure 5 illustrates the problem of the “whiplash” effect in the case of a cable anchoring system comprising a circular drum with an axis of rotation of the drum relative to the frame offset with respect to the center of the circle;

- figure 6 illustrates an embodiment of the cable anchoring system in which said system comprises a drum having an elliptical shape and an axis of rotation offset with respect to the center of the ellipse along with a compression spring suitable for damping a travel of the cable by winding and/or unwinding of the cable around a portion of the ellipse;

- figure 7 shows a particular embodiment of a torsion spring;

- figure 8A and figure 8B show a particular embodiment of the anchoring system of the invention in which said system comprises a drum having an elliptical shape and an axis of rotation offset with respect to the center of the ellipse along with four torsion springs suitable for damping a travel of the cable by winding and/or unwinding of the cable around a portion of the ellipse and arranged along the axis of rotation of the drum so as to allow the rotation of said drum in relation to the frame.

For reasons of legibility, the drawings are not necessarily to scale.

DETAILED DESCRIPTION OF EMBODIMENTS

The invention relates to a drum suitable for being mounted on a frame and for anchoring a cable to said frame.

With reference to figures 1A, 1B and 1C, the frame 2 is preferably a frame suitable for being mounted on a spreader 4, said spreader 4 comprising one or more fastening members 5, said fastening members being suitable for picking up a load. The fastening members 5 of the spreader 4 may for example comprise four twist locks suitable for gripping a container. When it is in use, the spreader 4 is connected to a lift machine 6, for example a crane, by lifting means 7 of said spreader 4, said lifting means 7 being suitable for allowing the movement of the spreader 4 in relation to the lift machine 6, typically the ascent or descent of said spreader 4, said movement being able to be remotely controlled by an operator, for example a crane driver positioned in the driver's cabin or in a driving room from which he controls several cranes alternately. Alternatively, said movement can be managed completely automatically without the involvement of said operator. The lifting means 7 of the spreader 4 may comprise ropes and one or more motors mounted on the lift machine 6.

According to an embodiment not shown on figures 1A, 1B and 1C, a second spreader can be connected to the lift machine 6 by lifting means of said second spreader, said lift machine 6 further comprising an intermediate platform. Such a configuration is particularly advantageous when the item of lifting equipment is an STS crane: the spreader 4 is used to move a container between the ship and the platform while the second spreader is used to move said container between the platform and the dock.

The cable 3 comprises one or more conductive links for power and/or data transfer. Each conductive link can take the form of an electrically conductive wire, an optical fiber, or any other appropriate form. Preferably, the cable comprises at least a conductive link for supplying power and a conductive link for controlling the fastening members 5 of the spreader 4. When the drum 1 is in use, i.e. when the drum 1 is mounted on the frame 2, the frame 2 mounted on a spreader 4 and the spreader 4 connected to a lift machine 6, a first end of the cable is anchored to the frame 2 by way of the drum 1 and a second end of the cable 3 is wound around a winder mounted on the item of lifting equipment 6. More precisely, the drum according to the invention comprises a lateral surface (S) located around an axis (Y), such that when the drum 1 is in use, the first end of the cable 3 is wound around said lateral surface (S).

The winder mounted on the item of lifting equipment is typically an electronically-controlled winder comprising a motor which winds or unwinds the cable so as to keep the cable taut whatever the operating phase of the spreader (for example in ascent, descent, setting in motion or stopping). A control unit computes a torque setpoint to be applied according to said

operating phase. The value of the torque must be high enough to keep the cable taut without damaging the cable. The torque setpoint is sent to a frequency variator which translates said torque setpoint into a current to be imposed on the motor. A variation in the torque setpoint, for example when the position of the spreader changes or the operating phase changes, causes a variation in the motor current. Such a control loop has a non-zero reaction time which is the sum of at least a reaction time related to the electronics and a reaction time related to the conversion of the current setpoint. The reaction time related to the electronics is estimated as being in the order of 75 ms. This reaction time does not allow the winder to respond quickly enough in certain situations, for example in the event of sudden movements of the spreader, or for example in the event of impacts or gusts of wind, thus generating tension in the cable.

The drum 1 is therefore suitable for being mounted rotatably on the frame 2 about an axis of rotation (X) parallel to the axis (Y), so that when the drum 1 is in use, the drum 1 can be freely rotated about the axis of rotation (X) under the effect of a tension in the cable 3 not immediately compensated for by the winder, thus allowing the travel of the cable 3 by the winding and/or unwinding of said cable around the lateral surface (S) along a portion of the lateral surface (S).

More precisely, the drum, in a position described as neutral, can be subjected to a tensile force from the cable due to the torque imposed on said cable by the winder, making it possible to keep said cable taut. A mechanical tension of the cable is understood to mean a variation of the tensile force applied by the cable to the drum in relation to the tensile force applied to said drum in the neutral position. It can be an under-tensile force (configuration corresponding to cable slack) or an over-tensile force (configuration in which the winder pulls on the cable with a higher amount of tensile force than the theoretical value resulting from the setpoint). Such a mechanical tension will cause a rotational movement of the drum about the axis of rotation (X) with respect to this neutral position. In the under-tensile force case, the rotational movement about the axis of rotation (X) will be done in the direction of winding to pick up the cable slack until, optionally, a first stop position is reached. In the over-tensile force case, the rotational movement about the axis of rotation (X) will take place in the direction of unwinding of the cable to release the cable until, optionally, a second stop position is reached.

Preferably, the drum is arranged so that during the use of said drum, a first part of the first end of the cable remains wound around said surface (S) in all the phases of use of the frame, and a second part of said cable in the extension of the first part winds and/or unwinds along the portion of the lateral surface (S) due to the rotational movement of the drum about the axis of rotation (X) between the first and second stop position. By way of example, the first part of the first end of the cable has a length at least equal to two full turns of the surface (S), preferably greater than two and a half turns. The first part of the first end is advantageously

long enough to cancel out the tensioning of the cable at the end of said cable by a so-called capstan effect. In a manner known *per se*, the capstan effect establishes the ratio between a retaining force applied to one end of a cable wound around the lateral surface of a cone, said cone being able to have a circular or non-circular section (for example an elliptical section) and a load force applied to an opposite end of said cable which depends on the frictional coefficient of the cable on the lateral surface of the cone.

The drum 1 is characterized in that at least a first bend radius of a first portion 14 of the lateral surface (S) measured in a plane (P) perpendicular to the axis of rotation (X) is strictly greater than at least a second bend radius of a second portion of the lateral surface (S) measured in the same plane (P). The drum 1 is arranged so that, when it is mounted on a frame 2, the winding and/or unwinding of said cable 3 around the lateral surface (S) due to the rotational movement of the drum 1 about the axis (X) between the first and the second stop position occurs along the first portion 14. In other words, the useful portion of said drum 1 is limited to the portion of large bend radius.

By way of example, the lateral surface (S) in the plane (P) has an ovoid or ellipse shape, or any other shape whose the bend radius is not constant. Thus, the shape of the lateral surface (S) in the plane (P) is not a circle.

The lateral surface (S) can be smooth, so that it has, in the plane (P), a single tangent at any point. The lateral surface (S) thus has a curved shape, exactly corresponding to the ellipse or ovoid shape previously described. For this purpose, the lateral surface (S) can be formed by rolling a metal sheet. Alternatively and without departing from the scope of the invention, the lateral surface (S) can have many facets parallel to the axis of rotation of the drum, so that it has, in the plane (P), a polygonal shape contained in the shape of non-constant bend radius, for example the ellipse or ovoid shape. In other words, the lateral surface (S) has the overall shape, in the plane (P), of an ellipse or an ovoid. For example, the lateral surface (S) can be formed by prebending of a metal sheet, i.e. by successive folding of the metal sheet.

The drum 1 is advantageously less bulky than a drum comprising a lateral surface (S) having, in the plane (P) perpendicular to the axis of rotation (X), the shape of a circle (C1) tangent to the first portion 14 and of radius equal to the first bend radius (R1), while allowing the cable a greater amount of travel along the first portion 14 than would be allowed by a drum 1 with the same first and second stop position and comprising a lateral surface (S) of which the shape in the plane (P) is a circle (C2) of radius equal to the second bend radius (R2) for a same lateral bulk on the frame.

Figures 2A and 2B show examples of lateral surfaces (S) respectively having ovoid and ellipse shapes in the plane (P) (plane of figures 2A and 2B) and compare said ovoid and ellipse with the circles (C1) and (C2).

Figure 3 shows the example of a drum 1 having an ellipse shape in the plane (P) in use on a frame. In particular, the center of figure 3 shows the configuration in which the drum 1 is in a neutral position. The bottom of figure 3 shows the scenario of an under-tension of the cable 3: the drum 1 turns from said neutral position in the direction of winding of said cable 3 about the axis of rotation (X) to wind up the cable slack. The top of figure 3 shows the scenario of an over-tension of the cable 3: the drum 1 turns from the neutral position in the direction of unwinding of the cable 3 about the axis of rotation (X) to unwind the cable.

The ellipse has a large height, but a very small width. If there is no particular point in reducing the former, since it is not very restrictive, the second must be limited so as to be able to mount the drum 1 on a frame of small size. The ellipse is therefore a particularly advantageous shape for the drum 1.

In the particular embodiment shown on figure 3, the axis of rotation (X) intersects with the plane (P) at the center of the ellipse.

Alternatively, one may consider the circle (C1) of a length of radius equal to the first bend radius (R1) of the first portion 14 and tangent to said first portion 14 (circle shown on Figure 2B; the first portion 14 is shown there in bold). The center of said circle (C1) is denoted (O1). Advantageously, the axis of rotation (X) intersects with the plane (P) at an intersection point (A) located at a distance from the center (O1) of the circle (C1) of between 0% and 10% of the value of the first bend radius. In other words, the axis of rotation (X) is placed close to the center (O1) of the circle (C1) tangent to the first portion 14 with a radius equal to the first bend radius.

Preferably, the axis of rotation (X) intersects with the plane (P) at the intersection point (A) which is located at a distance from the center (O1) of the circle (C1) of between 0% and 5% of the value of the first bend radius, the first portion 14 being centered around the intersection point (A). The fact that the first portion 14 is centered around the intersection point (A) should be understood to mean that the intersection point (A) is located on the circle radius (C1) tangent to the first portion 14 which intersects with the arc forming the first portion 14 at its middle.

For example, the intersection point (A) between the plane (P) and the axis of rotation (X) is located on the half-minor axis of the ellipse opposite the first portion of the lateral surface (S) with respect to the center of the ellipse.

Still preferably, the intersection point (A) and the center (O1) of the circle (C1) tangent to the first portion 14 and of radius equal to the first bend radius coincide.

By way of example, figure 4 shows the special case in which the lateral surface (S) has, in the plane (P), an ellipse shape and in which the intersection point (A) coincide with the center (O1) of the circle (C1) tangent to the first portion and of radius equal to the first bend radius. The middle of figure 4 corresponds to the configuration in which the drum is in a neutral position, the top of figure 4 is the scenario of an under-tension of the cable and the bottom of figure 4 is the scenario of an over-tension of the cable. The intersection point (A) is in this case distinct from the center of the ellipse, and said center of the ellipse is globally located between the first portion and the intersection point (A). The placing of the axis of rotation (X) close to the center (O1) of the circle (C1) tangent to the first portion and of radius equal to the first bend radius or directly on said center (O1) causes said axis of rotation (X) to be further away from the first portion by comparison with the case where it is placed at the center of the ellipse.

For a given lateral surface (S), and a fixed angle between the first and the second stop position, an axis of rotation (X) further from the winding/unwinding portion allows the cable a greater amount of travel. In other words, the length l of the first portion 14 measured in the plane (P) is greater. Reciprocally, for a given amount of travel, the offsetting of the axis of rotation (X) by positioning it further away from the first portion 14 will require a smaller angle between the first and the second stop position. Positioning the axis of rotation (X) further away from the winding/unwinding portion is therefore particularly advantageous when the angle between the first stop position and the second stop position is restricted and cannot exceed a maximum value, for example due to the springs for absorbing the force of the cable 3 on the drum 1.

In the case of a lateral surface (S) having, in the plane (P), the shape of a circle of radius limited by the size of the frame on which the drum must be arranged (for example said radius is equal to the second bend radius), the offsetting of the axis of rotation (X) with respect to the center of the circle is known by those skilled in the art to allow, at a constrained angle between the first and the second stop position, an increase in the length of travel allowed the cable. However, the passage from the neutral position to one or the other of the stop positions, and vice versa, in this case causes a significant variation in the distance d' measured in the plane (P) between the cable and the straight line of the plane (P) parallel to said cable which

intersects with the axis of rotation (X), thus generating sudden surges of “waves” from the cable to the winder, or in other words the rapid propagation of a transverse displacement of the cable along the length of the cable toward the winder (see figure 5). If there are means for protecting the winder from such cable waves (for example guardrails), these means are not sufficient for frequent or high-amplitude cable waves.

The feature according to which the drum 1 is suitable for the winding and/or unwinding of a cable 3 along a first portion of a lateral surface (S) of said drum 1, said first portion 14 having a first bend radius greater than a second bend radius of a second portion of the lateral surface (S), combined with the position of the axis of rotation (X) close to the center (O1) of the circle (C1) tangent to the first portion and of radius equal to the first bend radius makes it possible, for an angle constrained between the first and the second stop position, to allow the cable 3 a large amount of travel while limiting this “whiplash” effect which can damage the cable 3 or expel the cable 3 from the winder when the cable wave arrives at said winder.

The “whiplash” effect is more successfully avoided when the intersection point (A) is closer to the center (O1) of the circle (C1) and the first portion 14 centered around the intersection point (A) (which can be seen by comparing figure 3 on which the axis of the cable 3 depends on the rotation of the drum 1 and figure 4 on which it does not depend on this rotation).

According to a particular embodiment of the invention, the first portion 14 comprises the point of maximum bend radius of the lateral surface (S) measured in the plane (P), and/or the average bend radius of the first portion 14 measured in the plane (P) is greater than or equal to the average bend radius measured in the same plane (P) of any portion of the lateral surface (S) of the same length as the first portion, the length of the portions being measured in said plane (P), and/or in which the first portion 14 is the flattest portion of the lateral surface (S) of length l measured in the plane (P).

Such a configuration advantageously makes it possible, for a given lateral surface (S) and a fixed angle between the first stop position and the second stop position, to obtain the greatest amount of travel and most successfully avoid the “whiplash” effect previously described.

In the special case in which the lateral surface (S) in the plane (P) has an ovoid shape, the first portion 14 of the lateral surface (S) is preferably contained in the part of the ovoid opposite the portion of smallest bend radius of the ovoid. In other words, by comparing the ovoidal shape to that of an egg, the portion of smallest bend radius is the tip of the egg, so the

first portion 14 is therefore preferably contained in the foot of the egg (see bold portion on figure 2A).

In this configuration, the ovoid has the advantage of being able to keep the axis of rotation (X) away from the first portion 14 while keeping the intersection point (A) of the axis of rotation (X) in the plane (P) inside the lateral surface (S).

In the special case where the lateral surface (S) in the plane (P) has an ellipse shape, the first portion 14 of the lateral surface (S) is preferably contained in one of the two arcs of the ellipse delimited by the major axis of said ellipse (see figures 2B, 3 and 4).

According to a particular embodiment of the invention, the length l of the first portion 14 of the lateral surface (S) measured in the plane (P) is greater than 300 mm, preferably greater than 600 mm, so as to allow the cable 3 a travel from the neutral position of at least 300 mm in the direction of winding of the cable and of at least 300 mm in the direction of unwinding of the cable.

Indeed, the inventors consider that the ideal amount of travel for the cable from the neutral position is the product of the maximum speed of the spreader by the reaction time of the feedback loop of the electronically-controlled winder. The maximum linear speed given by the motors to the spreader is typically between 150 m/min or 2.5 m/s and 240 m/min or 4 m/s. The reaction time of the electronically-controlled winder being, as stated previously, in the order of 75 ms, the travel from the neutral position is therefore ideally of 300 mm both in the direction of unwinding and winding of the cable on the drum. A non-constant bend radius of the lateral surface (S) of the drum advantageously makes it possible to obtain such travel with an acceptable bulk of said drum on the frame.

A length l of the first portion of the lateral surface measured in the plane (P) greater than 300 mm, with preferably a travel from the neutral position of 150 mm both in the direction of unwinding and winding of the cable on the drum, can be sufficient when the maximum linear speed given by the motors to the spreader is lower, for slower cranes.

The invention also relates to a cable anchoring system 3, comprising a frame 2 and a drum 1 according to one of the embodiments previously described, mounted rotatably on the frame 2 about the axis of rotation (X). The anchoring system according to the invention further comprises at least one spring for absorbing the forces generated by the travel of the cable 3 between the first and the second stop position arranged between the drum 1 and the frame 2.

Under the effect of the force applied to the spring due to the rotation of the drum 1 about the axis of rotation (X), said spring deforms. The arrangement of the spring between the drum and the frame is done such that the spring is in the middle of its deformation range when the drum is in the neutral position. This makes it possible to obtain an equivalent amount of travel in the direction of winding of the cable and in the direction of unwinding of the cable.

Preferably, the first and the second stop position are angularly offset with respect to the axis of rotation (X) by an angle between 0° and 60° and the middle of the deformation range of the at least one spring is located at 30° . According to a still-preferred embodiment, the first and the second stop position are angularly offset with respect to the axis of rotation (X) by an angle between 0° and 90° and the middle of the deformation range of the at least one spring is located at 45° .

According to an embodiment of the cable anchoring system shown on Figure 6, the at least one spring comprises a compression spring 8. In this embodiment, the cable anchoring system comprises at least one bearing 9 arranged around the axis of rotation (X), said at least one bearing being suitable for allowing the rotation of the drum 1 about the axis (X) in relation to the frame 2 between the first and the second stop position. The bearing comprises for example a ball bearing, or pads or any other rotational guide means. The compression spring is characterized by a length at rest, a maximum compression length less than the length at rest (length when its coils touch) and a stiffness constant. For a given stiffness constant, the angle between the first stop position and the second stop position is limited by the length at rest of the spring on the one hand and the maximum compression length on the other. For example, a spring of a length at rest between 200 mm and 250 mm typically makes it possible to attain an angle between the first stop position and the second stop position of between 15° and 20° . However, increasing the length of the spring equates to increasing the bulk of the anchoring system.

According to a preferred embodiment of the cable anchoring system, the at least one spring comprises a torsion spring.

In a variant, the anchoring system comprises a torsion spring arranged along the axis of rotation (X), a first part of said spring being rigidly connected to the frame and a second part of said spring being rigidly connected to the drum, the second part being suitable for pivoting with respect to the first part so as to permit the rotation of the drum about the axis of rotation (X). Thus arranged, the first and the second stop position may correspond to the end positions of pivot of the second part of the torsion spring in relation to the first part. According to a preferred alternative, the first and the second stop position are contained between the end

positions of pivot of the second spring part in relation to the first part. Not turning all the way to the end positions when the drum is in use advantageously avoids pointlessly reducing the lifetime of the torsion spring.

Such an arrangement of the torsion spring advantageously makes it possible to avoid using other means for mounting the drum rotatably in relation to the frame, such as roller bearings or pads. Specifically, said roller bearings or pads are not suitable for the conditions of use of the anchoring system mounted on a spreader (constant work over a limited angle of rotation without ever making any full turns, a great deal of vibration) and wear out quickly, limiting the lifetime of the anchoring system. Contrariwise, torsion springs, conventionally used in damping pads, are perfectly suited to such operating conditions. Furthermore, the use of torsion springs arranged along the axis (X) makes it possible to reduce the bulk of the anchoring system, particularly as regards the configuration in which at least one spring comprises a compression spring.

In another still preferred variant, the cable anchoring system comprises at least two torsion springs mounted in series and arranged along the axis of rotation (X), a first part of a first spring being mounted on the frame, a first part of a second spring being mounted on the drum, and a second part of the first spring being rigidly connected to a second part of the second spring.

For a given lateral surface (S), the arrangement of two torsion springs in series advantageously makes it possible to double the angle between the first and the second stop position with respect to the axis of rotation (X) and therefore to increase the length l of the first portion measured in the plane (P). In other words, this makes it possible to increase the travel allowed to the cable. Thus, if the angle between the first and the second stop position with respect to the axis of rotation (X) with a torsion spring is between 0° and 30° , the series mounting of two torsion springs advantageously makes it possible to increase the angle between the first and the second stop position to an angle between 0° and 60° . Such an angle of travel between the first and the second stop position is not reasonably achievable with a compression spring.

An angle of travel between the first stop position and the second stop position of between 0° and 60° makes it possible to sweep a first portion of a length between 0 and approximately 630 mm measured in the plane (P) when the first bend radius of the first portion of the lateral surface (S) measures 575 mm, the diameter of the cable measures 50 mm and the distance d' is advantageously equal to the first bend radius of said first portion of the lateral surface (S).

Specifically, the arc length of the first portion at the neutral fiber of the cable I can be calculated as follows:

$$l = \frac{2 \times (575 + 25) \times \pi \times 60}{360} = 628.32 \text{ mm} \cong 630 \text{ mm}$$

By way of example, with reference to figure 7, each torsion spring 10 may comprise a first metallic and hollow square-based prism 11, a second metallic and hollow square-based prism 12 housed inside the first prism 11 with an angular offset with respect to the first prism 11, and four elastomer cylinders 13 arranged between the first prism 11 and the second prism 12, in the corners of the first prism. In this case, the first prism 11 can be rigidly connected to the frame (reciprocally to the drum), and the second prism 12 to the drum (reciprocally to the frame). In the particular configuration in which two torsion springs are mounted in series, the inner second prism 12 of the first torsion spring can be connected to the inner second prism 12 of the second torsion spring, for example by an intermediate shaft. The outer first prisms 11 of the first and of the second torsion spring may themselves be connected to the drum and to the frame by external straps.

Still in the case where the angle between the first and the second stop position with respect to the axis of rotation (X) with a torsion spring is between 0° and 30°, the series mounting of three torsion springs advantageously makes it possible to increase the angle between the first and the second stop position to an angle between 0° and 90°.

In addition to the embodiments of the previously-described cable anchoring system, the at least one spring may comprise two parallel-mounted springs, a first part of the first and of the second spring being connected to the frame and a second part of the first and of the second spring being connected to the drum, each of the first and second springs being able to be understood as a single spring or as at least two series-mounted springs. For a same angle of rotation of the drum about the axis (X), parallel mounting advantageously makes it possible to avoid doubling the force of the springs. Furthermore, parallel mounting makes it possible to distribute the forces taken up on the frame on either side of the drum and thus to avoid shear forces on the springs.

By way of example, figures 8A and 8B show the particular configuration in which at least one spring comprises a first set of springs composed of a first torsion spring 10a series-mounted with a second torsion spring 10b and a second set composed of a third torsion spring 10c series-mounted with a fourth torsion spring 10d, the first set and the second set of springs being mounted in parallel with one another. Furthermore, the four springs are arranged along the axis of rotation (X).

The invention also relates to a lifting device comprising:

- a spreader 4,
- an anchoring system, comprising a frame 2 and a drum 1 as previously described, the frame 2 being attached to the spreader 4 and the drum 1 to the frame 2,
- a winder suitable for being attached to the item of the lift machine,
- a cable 3, a first end of the cable 3 being anchored to the drum 1 of the anchoring system by fixed winding of at least two turns around the lateral surface (S) of the drum 1 and a second end of the cable 3 being wound around the winder.

The static bend radius of the cable 3 is defined as the minimum bend radius of winding of the cable 3 recommended by the manufacturer of the cable 3 to avoid damage, loss of performance and/or a reduction in the lifetime of said cable 3. Storing the cable 3 wound along a bend radius smaller than the static bend radius runs the risk of generating stresses on the conductors contained in said cable 3, by compressing the conductors, for which the strength of the conductors was not tested by the manufacturer, and thus altering the internal geometry of the cable 3. The static bend radius of the cable 3 can be in the order of six times the diameter of the cable 3. The dynamic bend radius of the cable 3 is defined as being the minimum bend radius recommended by the manufacturer at which the cable 3 can be bent and unbent repeatedly during use without damaging it, reducing its performances and/or its lifetime. Specifically, if the cable 3 is repeatedly folded with a bend radius smaller than the dynamic bend radius, this runs the risk of generating rubs between insulators or between strands of a same conductor and mechanical tensioning of certain strands or conductors while other strands or conductors are in under-tension. Such an unbalance of forces can cause the strands to break. The breaking of the strands can itself lead to punctures in the insulating sheaths or the destruction of said sheaths by heating. The breaking of strands and damage to the sheaths can cause short-circuit problems and/or the cessation of the transmission of the signals or power conveyed by the damaged cables. The dynamic bend radius is strictly greater than the static bend radius of the cable 3.

According to a particular embodiment of the lifting device, the minimum bend radius of the lateral surface (S) of the drum measured in the plane (P) is greater than the static bend radius of the cable 3 and less than the dynamic bend radius of said cable. Specifically, since the portion of the lateral surface (S) of minimum bend radius is never unwound, such an embodiment advantageously makes it possible to limit the bulk of the drum as much as possible without damaging the cable. For example, the minimum bend radius of the lateral surface (S) is in the order of 330 mm. Such a value of the minimum bend radius

advantageously makes it possible to wind cables of a diameter between 35 mm and 55 mm for which the static bend radius is less than 330 mm.

According to a particular embodiment of the lifting device, the winder is an electronically-controlled winder and the length l of the first portion of the drum measured in the plane (P) is equal to the product of the maximum speed of the spreader by the reaction time of the control loop of said winder.

Finally, the invention relates to a lift machine 6 comprising a lifting device as previously described. According to a particular embodiment of the invention, the lift machine is a crane, a gantry or a forklift truck. The lift machine 6 is for example a crane used for loading or unloading containers on a container ship.

According to a particular embodiment of the lift machine 6, said lift machine 6 further comprises the lifting device as previously described, a second spreader and an intermediate platform. For example, the lift machine 6 is an STS crane and the spreader 4 of the lifting device 6 is used to move a container between the ship and the intermediate platform while the second spreader 1 is used to move said container between the platform and the dock.

In a particular embodiment of the lift machine 6 with two spreaders, the second spreader is contained in a second lifting device, said second lifting device being able to be embodied as claimed in any of the embodiments of the lifting device previously described.

Alternatively, the lift machine does not comprise any second winder or any second cable anchored to the second spreader from the second winder.

CLAIMS

1. A drum (1) suitable for anchoring a cable (3) to a frame (2), said drum (1) being suitable for being mounted rotatably about an axis of rotation (X) on said frame (2), the drum (1) having a lateral surface (S) around an axis (Y) parallel to the axis of rotation (X), the drum (1) being characterized in that the lateral surface (S) comprises a first portion (14) having at least a first bend radius measured in a plane (P) perpendicular to the axis of rotation (X) strictly greater than at least a second bend radius of a second portion of the lateral surface measured in said plane (P), the drum (1) being suitable for allowing a travel of the cable (3) by the winding and/or unwinding of said cable (3) around the lateral surface (S) along the first portion (14), by the rotation of said drum (1) about the axis of rotation (X) between a first and a second stop position.

2. The drum (1) as claimed in the preceding claim, wherein the axis of rotation (X) intersects with the plane (P) at an intersection point (A) located at a distance from the center (O1) of a circle (C1) tangent to said first portion (14) of between 0% and 10% of the value of a radius of the circle (C1), the radius of the circle (C1) being equal to the first bend radius (R1) of the first portion (14), the first portion (14) being centered around the intersection point (A).

3. The drum (1) as claimed in one of the preceding claims, wherein the first portion (14) comprises the point of maximum bend radius of the lateral surface (S) measured in the plane (P).

4. The drum (1) as claimed in one of the preceding claims, wherein the lateral surface (S) has, in the plane (P), an ovoid shape and wherein the first portion (14) of the lateral surface (S) is contained in the part of the ovoid opposite the portion of said ovoid with the smallest bend radius.

5. The drum (1) as claimed in one of claims 1 to 3, wherein the lateral surface (S) has, in the plane (P), an ellipse shape, and wherein the first portion (14) of the lateral surface (S) is contained in one of the two arcs of the ellipse delimited by the major axis of said ellipse.

6. The drum (1) as claimed in claim 5 in combination with claim 2 wherein the intersection point (A) between the plane (P) and the axis of rotation (X) is located on the semi-minor axis of the ellipse opposite the first portion (14) of the lateral surface (S) with respect to the center of the ellipse.

7. The drum (1) as claimed in one of the preceding claims, wherein the length (l) of the first portion (14) of the lateral surface (S) measured in the plane (P) is greater than 300 mm, preferably greater than 600 mm.

8. A cable (3) anchoring system, comprising a frame (2), a drum (1) as claimed in one of the preceding claims mounted rotatably on the frame (2) about the axis of rotation (X), and at least one spring (8, 10) for absorbing the forces generated by the travel of the cable (3) between the first and the second stop position arranged between the drum (1) and the frame (2).

9. The cable (3) anchoring system as claimed in the preceding claim, wherein the at least one force absorbing spring (8, 10) is a torsion spring or a set of two torsion springs (10a, 10b) assembled in series.

10. The cable (3) anchoring system as claimed in the preceding claim, wherein each torsion spring (10) comprises a first metallic and hollow square-based prism (11), a second metallic and hollow square-based prism (12) housed inside the first prism (11) with an angular offset with respect to the first prism (11), and four elastomer cylinders (13) arranged between the first prism (11) and the second prism (12), in the corners of the first prism (11).

11. The cable (3) anchoring system as claimed in the preceding claim, comprising two torsion springs (10a, 10b) in series, the second square-based prism (12) of the first torsion spring (10a) being connected to the second square-based prism (12) of the second torsion spring (10b).

12. The cable (3) anchoring system as claimed in one of claims 8 to 11, wherein the force absorption spring (10) is arranged along the axis of rotation (X) so as to permit the rotation of the drum (1) about the axis of rotation (X) with respect to the frame (2) between the first and the second stop position without any roller bearing or pad.

13. The cable (3) anchoring system as claimed in one of claims 8 to 12, of which the first and the second stop position are angularly offset with respect to the axis of rotation (X) by an angle between 0° and 60°, preferably between 0° and 90°.

14. A lifting device comprising:

- a spreader (4) comprising at least one fastening member (5) for fastening a load to be lifted,
- an anchoring system as claimed in one of claims 8 to 13 comprising a frame (2) and a drum (1) as claimed in one of claims 1 to 7, the frame (2) being attached to the spreader (4) and the drum (1) being attached to the frame (2),
- a winder suitable for being attached to a lift machine,

- a cable (3), a first end of the cable (3) being anchored to the drum (1) of the anchoring system by a fixed winding of at least two turns around the lateral surface (S) of the drum (1) and a second end of the cable (3) being wound around the winder.

15. The lifting device as claimed in the preceding claim, wherein the lateral surface (S) has a minimum bend radius in the plane (P) strictly greater than the static bend radius of the cable (3).

16. The lifting device as claimed in the preceding claim, wherein the winder is an electronically-controlled winder and wherein the length (l) of the first portion (14) of the drum (1) measured in the plane (P) is equal to the double of the product of the maximum speed of the spreader by the reaction time of a control loop of said winder.

17. A lift machine (6), such as a crane, a gantry or a forklift truck, comprising a lifting device as claimed in one of claims 14 to 16.