(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 2 362 021 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
31.08.2011 Bulletin 2011/35

(51) Int Cl.:
E02B 17/04 *(2006.01)* ***E21B 19/00*** *(2006.01)*

(21) Application number: **10154566.3**

(22) Date of filing: **24.02.2010**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO SE SI SK SM TR
Designated Extension States:
AL BA RS

(71) Applicant: **MT Højgaard A/S**
2860 Søborg (DK)

(72) Inventor: **Aksglæde, Jesper**
2870 Dyssegård (DK)

(74) Representative: **Holme Patent A/S**
Vesterbrogade 20
1620 Copenhagen V (DK)

(54) **A turning arrangement for turning an elongated element, method and uses of the turning arrangement**

(57) A turning arrangement serves for turning an elongated element (2) from a position where the elongated element forms one angle with a horizontal plane to another position where the elongated element forms a larger angle with the horizontal plane. The turning arrangement (1) comprises a crane (4) with a first support means (11) for during the turning operation lifting a first end (11) of the elongated element, a carrier (6) with a second support means (6) for simultaneously moving the second end (5) of the elongated element (2) towards the crane (4). The turning arrangement of the invention is not furnished with other means for supporting the elongated element (2) than said first and second support means (8;6). The turning arrangement is easy and safe to operate and can handle large and heavy pipes like a foundation pile to an offshore windmill.

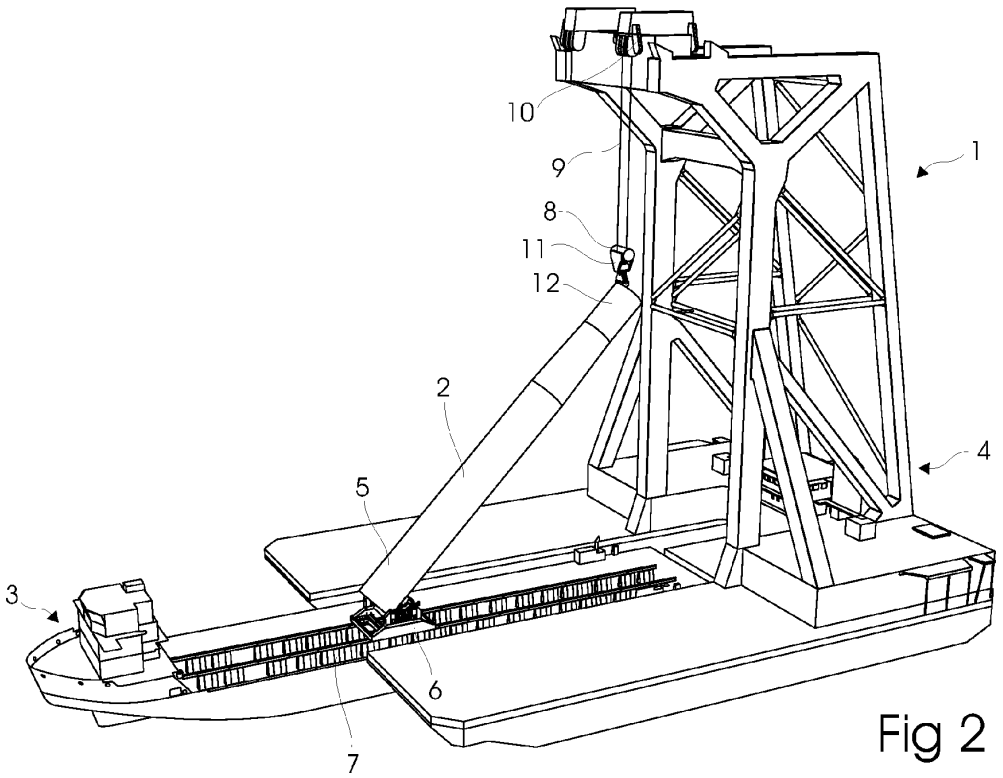


Fig 2

EP 2 362 021 A1

Description

[0001] The present invention relates to a turning arrangement for turning an elongated element from a position, where the elongated element forms one angle with a horizontal plane, to another position where the elongated element forms a larger angle with the horizontal plane.

[0002] The invention also relates to use of the turning arrangement and to a method of turning an elongated element from one position to another by means of the turning arrangement.

[0003] Within the scope of the present invention a typical "elongated element" is a foundation pile for a construction, e.g. an offshore construction. A foundation of e.g. an offshore windmill often utilizes a single foundation pile, which within the profession therefore often is given the term "monopile". However, in the following description the term "pipe" is generally used for the elongated element mentioned in the opening paragraph, but it should be understood that the term "pipe" covers any kind of elongated structure and is not limited to elongated structures having the same cross-section or specific cross-sections and/or lengths. Preferred elongated structures falling within the scope of the present invention are heavy load structures, such as monopiles.

[0004] A turning arrangement for turning a pipe from a horizontal to a vertical position is e.g. known from the patent application GB 2 137 261 A. This application teaches that a carriage, which is placed on a horizontal rail, supports a pipe to be turned from the horizontal position on the carriage to a vertical position on a drilling rig, equipped with a crane.

[0005] The crane comprises a winch provided with a wire rope. During the turning operation the carriage and the pipe will be hauled from the horizontal rail to a pivotable other rail by means of the wire rope. Said other rail extends from the end of the horizontal rail to the floor of a rig. Thereafter the other rail is pivoted to a vertical position and the pipe is removed from the carriage, during which operation the pipe has been turned from the horizontal position on the carriage to the vertical position on the rig. Hereafter the other rail and the carriage can be returned to their starting positions ready for a new turning operation.

[0006] However, this known construction of a turning arrangement for pipes is not only expensive to operate but also extremely complicated to use. Especially at heavy sea it can be extremely troublesome and demanding to ensure that the two rails are able to abut against each other precisely enough - and for sufficient time - to allow the carriage with the pipe pass the crossing between the two rails safely. The known turning arrangement is therefore hazardous to operate and if the operator tries to meet an acceptable lever of safety the turning operation becomes both time consuming and labour-intensive.

[0007] Furthermore, said known turning arrangement is moreover unsuitable for handling large and heavy pipes like the above-mentioned foundation pile and monopiles, because they have major load areas spread out over the arrangement.

[0008] Thus it would be advantageously to provide a turning arrangement having a large degree of flexibility, which can handle e.g. monopiles and at the same time meets the above-described disadvantages of the prior art.

[0009] It is therefore a first aspect of the present invention to provide a turning arrangement of the type mentioned in the opening paragraph adapted for handling large and heavy pipes, such as monopiles.

[0010] It is a second aspect of the present invention to provide a turning arrangement of the type mentioned in the opening paragraph which is simple, fast and inexpensive to operate.

[0011] It is a third aspect of the present invention to provide a turning arrangement of the type mentioned in the opening paragraph which is safe to operate, and at the same time meets the demands of providing a higher degree of flexibility than hitherto known.

[0012] It is a fourth aspect of the present invention to provide a turning arrangement of the type mentioned in the opening paragraph, which can be operated with a minimum of effort.

[0013] It is a fifth aspect of the present invention to provide a turning arrangement of the type mentioned in the opening paragraph, having a simple, inexpensive and maintenance free construction, allowing the overall size and weight of the arrangement to be reduced.

[0014] It is a sixth aspect of the present invention to provide a use of the turning arrangement according to the present invention.

[0015] It is a seventh aspect of the present invention to provide a method for turning an elongated element from one position to another by means of a turning arrangement according to the present invention.

[0016] Within the scope of the present inventions the terms "end of the elongated element" or "end of the elongated element" is to be understood as a portion of an elongated element, which merges into an end face of the elongated element or is in proximity or close to said end face.

[0017] Other aspects of the invention will be apparent during the course of the following description.

[0018] The novel and unique features wherein these and further aspects are achieved according to the present invention is the fact that the turning arrangement comprises

- a crane with a first support means for lifting a first end of the elongated element during the turning operation, and
- a carrier with a second support means for simultaneously with lifting said first end moving the second end of the elongated element towards the crane.

[0019] Thereby is obtained the advantage that the carrier of the turning arrangement according to the present invention advantageously supports only one end of the elongated element while the other end is supported by the crane. Further support means for e.g. supporting the entire length of the elongated element are unnecessary. In this respect it must be stressed that the turning arrangement of the prior art document GB 2,137,261A requires that the elongated element is supported in it's full length during the turning operation, i.e. when the elongated element is being hauled from the first rail onto a pivotable other rail where it is pivoted together with the other rail to a vertical position.

[0020] Said first and second support means can be the only support means supporting the elongated element during the turning arrangement.

[0021] Due to the fact that the turning arrangement according to the present invention requires only two supports means for performing a turning operation, one at each end of the elongated element, the turning arrangement constitutes an effective, easy operable, simple and inexpensive construction making the turning operation completely safe and inexpensive to carry out using only a minimum of manpower.

[0022] Moreover, since the turning arrangement is only supporting the ends of the elongated element, the elongated element will inevitable be statically determinated, and the orientation of the elongated element is secured and ensured during the turning operation. Furthermore, since no intermediate supports need to be operated, the turning operations will become extremely safe and at the same time be both easy to monitor and keep under control.

[0023] By the term "statically determinate" is within the scope of the present invention meant any structure whose reactions and forces can be determined by the following: the summation of all vertical and horizontal forces acting on the member or framework must be equal to zero, and the rotation causing moment about any point must be equal to zero. Said definition is adapted from Hugh Brooks Illustrated Encyclopedic Dictionary of Building and Construction Terms Englewood Cliffs, NJ: Prentice Hall, 1976.

[0024] The turning arrangement according to the invention will only be dependent on the strength of the carrier and the crane, and the turning arrangement can therefore easily be constructed and designed to handle large and heavy elongated elements, e.g. monopiles, as these are self-supporting between the first and second supports means according to the invention, owing to the large bending moment of the elongated element.

[0025] However, the turning arrangement according to the invention can within the scope of protection be used for handling any kind of elongated element, independently of size, shape, weight and intended use. Furthermore, the turning arrangement can be used on both land and sea.

[0026] In one embodiment according to the present invention the turning arrangement can be used for turning a foundation pipe for an offshore windmill from a horizontal to a vertical position. In said embodiment the turning arrangement will comprise a floating crane and a supply vessel for transporting the relatively heavy elongated element to the floating crane.

[0027] At the beginning the supply vessel will be loaded with the full weight of the elongated element. However, when the turning operation begins the carrier and the crane will each be loaded with a percentage of the total weight of the elongated element in dependence of the structural features and parameters of the elongated element along its length. Such features are for example the overall shape, length, cross sectional area and weight distribution of the elongated element, together with combinations of such features. For instance, if a relatively simple elongated element having substantially the same cross section along the entire length are to be turned from the horizontal to a vertical position, the supply vessel and the floating crane may each carry about half of the total weight.

[0028] Advantageously the supply vessel can be equipped with at least one elevating device for elevating or lifting at least the rear end of the elongated element. This will not only ensure that the carrier can be moved below the second end of the elongated element, but also that the second end of the elongated element afterwards can be lowered for being seated upon the carrier.

[0029] When the crane is a crane vessel, a crane ship or a floating crane, i.e. a ship with a crane specialized in lifting heavy loads on the sea, one floating crane can serve several supply vessels. This ensures that use of the turning arrangement according to the invention is both timesaving and cost-effective, e.g. when establishing offshore windmill farms. Pipes or monopiles can effectively be loaded on several supply vessels at the dock or harbour, then transported to the wind energy site where the floating crane is ready to turn one pipe after another to a vertical position. In contrast to prior art arrangements where the crane is located at the same vessel as the pipe, the unit capacity factor of the crane can be optimised since the crane does not need to return to the dock and retrieve a new pipe. The floating crane only needs to move the short distance to a new site where another supply vessel already is located with the next pipe to be turned. Thus only the lighter and faster moving supply vessel needs to shuttle between the wind energy sites and the dock or harbour to keep the floating crane in operation.

[0030] Since the arrangement according to the invention does not need to have major load areas spread out over the supply vessel or floating care, the overall size and weight of the arrangement can be significantly reduced compared to the known arrangements, ensuring that the arrangement is inexpensive and easy to operate.

[0031] The first support means of the crane may comprise a clamp attached to the free end of a wire rope of a crane winch for releasable clamping the first end of the

elongated element to the wire rope during the turning operation, thereby ensuring that the crane and the elongated element can be secured to each other in an easy, fast and reliable manner.

[0032] The second support means advantageously comprises a seat on which the elongated element is allowed to rest firmly during the turning operation, thereby ensuring that the second end of the elongated member does not slip on or off the carrier. The seat may be releasable mounted on the carrier in order to allow the seat to be secured on, at, or around the second end of the elongated member prior to being loaded on the carrier. The seat may be formed with a contact face upon which the second end of the elongated element can rest during the turning operation to achieve optimum control of the movement of the carrier and thus the turning of the elongated element.

[0033] In a preferred embodiment according to the present invention, the second end of the elongated element can be secured, at least in it's longitudinal direction, to the contact face of the seat using only frictional force. Frictional forces will be sufficient for keeping the second end of the elongated element safe and reliable secured at the carrier during the turning operation. The frictional contact creates an antiskid grip between the second end of the elongated element and the contact face of the seat. When the elongated element later is removed from the seat of the carrier after finalising the turning operation, no redundant securing parts needs to be removed first. The carrier of the turning arrangement according to the invention is therefore simple and inexpensive having an essentially maintenance free construction.

[0034] To promote and maintain an uninterrupted and unobstructed continuous turning operation of an elongated member using the carrier according to the invention, the carrier may be equipped with wheels adapted to run upon rails on the deck of the supply vessel. Said rails are preferably extending in the direction of the crane during the turning operation.

[0035] The seat can in one embodiment be pivotally mounted on the carrier about a pivot axis extending crosswise of a longitudinal axis of the elongated element, ensuring that the seat and the elongated element advantageously can turn in relation to the carrier, which maintains its horizontal position during the turning operation.

[0036] In a preferred embodiment the seat can be mounted on a cradle which instead of the seat itself can pivotally be mounted on the carrier advantageously ensuring that the elongated element can retain its desired turning position even if the supply vessel is heeling in relation to the crane.

[0037] Specifically this can be achieved if seat and cradle are interconnected by means of a slewing bearing having a rotating axis extending crosswise of both said pivot axis and the longitudinal axis of the elongated element. This will ensure that the seat can rotate at any angle in relation to the cradle. The carrier with the cradle and seat is thereby allowed to heel over while the elongated element in the seat maintains any desired arbitrary turning position necessary for performing the turning operation.

[0038] The supply vessel and floating crane will in e.g. heavy sea move up and down in relation to each other. In one embodiment the cradle with the seat can in order to compensate for said movement be mounted on at least one slide, arranged for moving up and down in at least one upstanding guideway on the carrier.

[0039] In a preferred embodiment the cradle can be mounted on two slides, each of which may be designed like an inverted U comprising a crossbeam extending into the moving direction of the carrier and two legs descending from the crossbeam for leaving space for means adapted to rise and lower each slide. Such means can e.g. be at least two hydraulic cylinders, one for each slide.

[0040] The turning arrangement can according to the invention comprise a system for compensating for changes in the load on the supply vessel during the turning operation and the subsequently unloading of the elongated element from the vessel. Said system can include means for ballasting the supply vessel in order to improve the stability of the vessel, which automatically will ensure a safer turning arrangement than hitherto known and improve the working conditions for the operators of the arrangement according to the invention.

[0041] The turning arrangement according to the present invention provides a turning arrangement wherein one or more individual supply vessels co-operate with a crane during the turning of the elongated elements from the supply vessels. The elongated element can be kept reliable secured to both the first support means and the second support means, without being substantially affected - or only being affected to a negligible extent - by the motions of the waves during said operation. Therefore, the arrangement according to the invention not only has a simple and inexpensive construction, but also has a simple and user-friendly design, making it extremely easy and safe to operate while at the same time optimising the output of the arrangement.

[0042] Even when the crane is a floating crane, the operator is able to access the first end of the elongated element without any notable problems. The arrangement is preferably designed such that the operator is provided with a clear view to securely couple the first support means to the first end of the elongated element. Furthermore, the uncontrollable impact from the waves is substantially eliminated and/or neutralized by the above-discussed features of the turning arrangement. The operator further has sufficient freedom to move around the first end of the elongated element for securing the first support means in a manner safe for both himself and reliable for subsequent turning of said elongated element. In an expedient and fast manner the two confronted vessels, i.e. the supply vessel with the elongated element to be turned and the floating crane for keeping control of the first end of the elongated element is confronted. Thereby is not only ensured that the first end of the elongated element

is exposed allowing it to be accessible in an easy and safely manner when being secured to the first support means on the crane but also that further guiding and controlling of the second end of the elongated element is simple and easy as the crane keeps the position of the first end securely at the intended site.

[0043] The invention further relates to a method for during use of the turning arrangement according to the invention, turning an elongated element from a position where the elongated element forms one angle with a horizontal plane to another position where the elongated element forms a larger angle with the horizontal plane.

[0044] The method comprises the steps of,

- laying the elongated element upon a support, thereby forming one angle with the horizontal plane,
- connecting a first end of the elongated element to a crane,
- placing the second end of the elongated element on a carrier adapted to move on the support towards the crane, and
- lifting the first end of the elongated element by means of the crane while the elongated element itself simultaneously is dragging the carrier with the second end of the elongated element towards the crane until the elongated element arrives at a position forming another angle with a horizontal plane.

[0045] The method according to the invention makes it possible to raise an elongated element at sea, such as e.g. the foundation and/or tower of a windmill, using simple, inexpensive means and eliminating the need for the elongated element to be supported on one or more midway location along the length of the elongated element as with the conventional systems.

[0046] The support can be any kind of support e.g. of a support vessel or other transport means for the elongated element.

[0047] In a preferred embodiment the method comprises the steps of,

- positioning a floating crane on the position at sea where the elongated element is to be placed,
- shipping the elongated element on a supply vessel in a horizontal position to the floating crane,
- releasable fixing a clamp attached to the free end of a wire rope of a crane winch to the first end of the elongated element,
- releasable fixing the second end of the elongated element to a pivotable support on the carrier, and
- activating the winch of the crane.

[0048] By means of this method is advantageously obtained that the first end of the elongated element, which is clamped to the free end of the wire rope, can be lifted upwards while the second end of the elongated element, fixed to the carrier, can be drawn towards the crane until the elongated element is placed in the vertical position.

[0049] For example, the elongated element can be a foundation pile for an offshore windmill, which foundation pile is turned from a horizontal to a vertical position using the method according to the present invention. Said method will be explained in more detail with reference to the drawing in order to fully clarify the individual steps of the method to the skilled persons.

[0050] To keep the supply vessel as steady as possible during the turning operation the supply vessel may advantageously be further ballasted concurrently with the progressive turning of the elongated element from a horizontal to a vertical position, in order to provide sufficient counterbalance during movement of the elongated element towards the floating crane.

[0051] The invention will be explained in greater details below, giving further advantageous features and technical effects and describing exemplary embodiments with reference to the drawing, in which

Fig. 1 is a perspective view of the turning arrangement according to the invention in an initial phase of the turning operation,

Fig. 2 shows the same as in fig. 1, with the turning arrangement in an intermediate phase of the turning operation,

Fig. 3 shows the same as in fig. 1, with the turning arrangement in a final phase of the turning operation,

Fig. 4 is, seen in perspective in a larger scale, an exploded view of a carrier of the turning arrangement shown in fig. 1,

Fig. 5 is a perspective view of the carrier shown in fig. 4 in assembled state with the carrier in the initial phase of the turning operation,

Fig. 6 shows the same as in fig. 5, with the carrier in the intermediate phase of the turning operation,

Fig. 7 shows the same as in fig. 5, with the carrier in the final phase of the turning operation, and

Fig. 8 shows the same as in fig. 4 in an assembled state seen in perspective from behind with the carrier in the final phase of the turning operation.

[0052] The turning arrangement of the invention shown in the figures is intended to be used in situations where an elongated element like a elongated element such as a monopile needs to be turned from a position where the elongated element forms one angle with a horizontal plane to another position where the elongated element forms a larger angle with the horizontal plane.

[0053] By way of example it is however in the following assumed that the turning arrangement of the invention is used for handling an elongated element, such as a

foundation pile in form of a pipe to an offshore windmill (not shown). However, this assumption is not to be construed as limiting, and the turning arrangement can just as easily be used for turning other elongated members on both land and at sea.

[0054] Pipes used as foundation piles for offshore windmills are often relatively large and heavy. The diameter of a pipe can be between four and six meter and the weight up to about 700 tons, it is therefore relevant to ensure that the turning arrangement according to the invention is both stable and secure during its use.

[0055] Fig. 1, 2 and 3 shows the turning arrangement 1 according to the invention seen in three successive steps while turning the pipe 2 from a horizontal to a vertical position.

[0056] The pipe 2 is loaded upon a supply vessel 3 using conventional means known to a person skilled in the art, and is thereafter shipped in an at least mainly horizontal position to a floating crane 4 being at anchor at the location were the offshore windmill is to be placed.

[0057] The detailed construction of the supply vessel and the floating crane is not part of the invention and will therefore not be discussed furthermore here, however it will be understood that both the supply vessel and the floating crane can have any suitable design capable of performing the designated functions of the turning arrangement according to the invention. Such designs are well known for the person skilled in the art.

[0058] In order to serve as foundation pile for the offshore windmill the pipe need to be turned from the horizontal position on the supply vessel 3 to a vertical position on the floating crane 4 in which position the pipe is then unloaded from the supply vessel by means of the floating crane 4.

[0059] In fig. 1 is the rear end 5, the second end, of the pipe 2 resting on a carrier 6 movable placed on rails 7 extending into the direction of the crane 1.

[0060] The supply vessel 3 is furnished with an elevating device (not shown) adapted to elevate at least the rear end 5 of the pipe 2 in order to ensure that the carrier 6 can be moved underneath said rear pipe end 5, hereafter the elevating device lowers the rear pipe end 5 until it rests upon the carrier 6.

[0061] The floating crane 4 comprises a winch 10 with a wire rope 9. To the free end 8 of said wire rope 9 is attached a clamp 11 for releasable securing the leading end 12 of the pipe 2 to the wire rope 9.

[0062] In fig. 1 the leading end 12 of the pipe has been secured to the wire rope 9. When the winch 10 on the crane 4 is activated that turning operation begins, transferring a part of the load on the supply vessel 3 to the crane 4.

[0063] Said transferred part of the load will be half the weight of a pipe 2 having a constant cross section along its length. However, in the situation shown in fig. 1, 2 and 3 said load would be less than half as the pipe 2 is tapering in the direction of the leading end 12 of the pipe 2.

[0064] The turning arrangement comprises a compensation system (not shown) for compensating for the reduced load on the supply vessel. Thereby is prevented that the supply vessel 3 rides too high and unstable in the sea ensuring that the extensive forces acting on the turning arrangement 1 from the impact of the waves is at least substantially reduced.

[0065] The power needed for turning the pipe is provided solely by the crane, which in fig. 2 has lifted the leading end 12 of the pipe 2 while the carrier 6 on the supply vessel 3 simultaneously is supporting the rear end 5 of the pipe 2.

[0066] The pipe 2, which is now forming an angle with a horizontal plane, is statically determined since it is simply supported at its ends. Therefore, lifting the leading end 12 of the pipe 2 by means of the crane 4 causes the pipe 2 itself to draw the carrier 6 with the rear end 5 of the pipe 2 into the direction of the crane 4 while moving along the rails 7.

[0067] In fig. 3 the pipe 2 has been turned to the desired vertical position whereby unloading of the pipe 2 from the carrier 6 automatically starts in a way, which will later be explained in further details.

[0068] Fig. 4 is, seen in perspective, an enlarged exploded view of the carrier 6 shown in fig. 1, 2 and 3. Fig. 5, 6 and 7 shows the carrier 6 in an assembled state in the same steps as in fig. 1, 2 and 3 respectively, where the pipe 2 is turned from a horizontal position to a vertical position.

[0069] Each corner of the carrier 6 is mounted with a bogie 13 each of which has two wheels 14 for allowing the carrier to run along the rails 7 fixed on the deck of the supply vessel 3. Each bogie 13 is suspended on the carrier 6 by means of an axel journal 13' placed halfway between the two wheels 14 for thereby securing that the load from the carrier 6 is distributed equally upon the two wheels 14 of the bogie 13.

[0070] The pipe 2 is during the turning operation according to the present invention resting upon a friction face 15 of a seat 16 mounted on the carrier 6. The friction face 15 is placed on two opposite walls 17 of the seat 16 forming an angle less than 180 degrees with each other, thereby ensuring that the pipe 2 is kept securely in place across the seat 16 during the complete rotating. An upstanding rear wall 18 formed on the rear end of the seat serves as backstop for the pipe.

[0071] The material of the friction face 15 is selected to have a friction coefficient ensuring that the forces of friction acting between the pipe 2 and the friction face 15 is substantially larger than the resistance meeting the carrier 6 running along the rails 7 during the turning operation.

[0072] The difference between said two friction forces ensures that the pipe 2 is secured to the seat 16 in the longitudinal direction of the pipe only by means of friction forces, whereby the turning arrangement according to the invention advantageously obtains that the pipe 2 immediately can be released from the seat 16 when the pipe is unloaded after having been turned to the vertical

position.

[0073] The seat 16 is mounted on the carrier 6 via a cradle 19 adapted to pivot about an axis 20 extending crosswise to the pipe 2 seated with its rear end 5 in the seat 16. The seat 16 and the cradle 19 are interconnected by means of an upper part 21 and lower part 22 of a slewing bearing 21, 22 allowing the seat 16 to rotate in relation to the cradle about an axis 23 extending crosswise on the seat 16 and the cradle 19.

[0074] Thereby, the seat holding the rear end 5 of the pipe 2 will be able to rotate in relation to the carrier 6 with the advantageously result that the pipe 2 will be able to retain its intended positions during the turning operation. This will not only ensure that stress components and stress concentration in response to increasing and reducing weight load on the carrier will be distributed evenly over the carrier but also that risk of material fatigue will be reduced or even eliminated.

[0075] The cradle 19 is pivotally suspended on two slides 24 placed at each side of the carrier 6 by means of axle journals 25. Said journals are mounted on the cradle 19 and fits into a bearing 26 formed in each slide 24. The slides are mounted for up and down movements in relation to the carrier 6.

[0076] In the embodiment shown each slide 24 is constructed like an inverted U comprising a crossbeam 27 extending into the running direction of the carrier and two legs 28 descending from the beam.

[0077] At each side of the carrier is formed an upstanding guide-way 29 for mounting the slide 24 placed at the respective side. At each side of each guideway is placed an upstanding rail 30 and each slide 24 is equipped with upper- and lower rollers 31, 32 for allowing the slide to roll up and down the rails 30 of the guide-way 29.

[0078] A first set of hydraulic cylinders 33 with piston rods 34 is acting between the carrier 6 and the crossbeam 27 of each slide 24. A second set of hydraulic cylinders 35 is acting between a protruding arm 36 fixed on each slide 24 and a moment arm 37 fixed on each cradle 19.

[0079] Fig. 5, 6 and 7 shows in a larger scale the carrier 6 shown in fig. 1, 2 and 3 while performing the same respective operationally steps. The supply vessel 3 has been lined up in relation to the floating crane 4 so that the rails 7 on the deck of the supply vessel are directed against the floating crane 4.

[0080] The rear end 5 of the pipe 2 is in fig. 5 resting on the seat 16, which is placed in a horizontal position since the pipe 2 is placed in a horizontal position. The lifting power P produced by the floating crane 4 is via the pipe 2 dragging the carrier 6 by means of the rear end 5 of the pipe 2 into the direction of the crane 4, i.e. into a horizontal direction while the carrier 6 is running on the rails 7 towards the floating crane 4.

[0081] The position of the rear end 5 of the pipe 2 will thereby safely be retained in the seat 16 owing to the fact that the friction between the fiction face 15 of seat 16 is substantially larger than the running resistance meeting the carrier 6 running on the rails 7.

[0082] The lifting power P of the crane has in fig. 6 lifted the leading end 12 (not seen in fig 6) of the pipe 2 upwards while the carrier 2 simultaneously has travelled a distance along the horizontal rails 7 ensuring that the pipe 2 now has been turned an angle from the horizontal position shown in fig. 1.

[0083] The seat 16 has been turned the same angle from the horizontal position shown in fig. 1, which turning is possible because the seat 16 is connected to the cradle 19, which again is pivotable connected to the slides 24 movable mounted upwards and downwards in the guideways 29 of the carrier 6.

[0084] The supply vessel 3 and the floating crane 4 will in sea perform up-and-down going motions relative to each other. Under such circumstances the turning of the pipe is difficult and troublesome or in some cases even impossible to carry out, especially in heavy sea.

[0085] However, the mutual motions of the supply vessel and the floating crane will be compensated for at least partly, due to the fact that the carrier travels forwards along the rails when the supply vessel moves downwards in relation to the floating crane. Accordingly the carrier will travel backwards along the rails if the floating crane moves upwards.

[0086] When the pipe is getting closer to the vertical position said motions of the carrier, i.e. forwards or backwards along the rails of the supply vessel, will however not be sufficiently to compensate for said relative up and down movements of the supply vessel and the floating crane. Since the impact of the waves now will be transferred at least to some extend to the pipe via the carrier very heavy forces will be acting on the connection between the pipe and the carrier whereby the carrier and likely more parts of the turning arrangements are at risk of been damaged or destroyed. That problem is according to the invention solved by means of the first set of hydraulic cylinders 33, which as previously mentioned are acting between the carrier 6 and the slides 24.

[0087] The turning arrangement 1 comprises a compensation system (not shown) which will active the hydraulic cylinders 33 during the turning operation ensuring that the slides 24 is pushed upwards in the guide-way 29 of the carrier 6 concurrently with downwards motions of the supply vessel 3 in relation to the floating crane 4, and downwards in the guide-ways 29 concurrently with upwards motions of the supply vessel 3 in relation to the floating crane 4.

[0088] The carrier 6 with the rear end 5 of the pipe 2 will in this way remain at least substantially at the same level in relation to the floating crane irrespective of the motions of the supply vessel up and down. This ensures that the carrier and the hydraulic cylinders effectively compensates for the mutual up and down motions of the supply vessel and the floating crane when the pipe is approaching a vertical position.

[0089] This compensation system can be operated manually but is preferably automatically operated.

[0090] In fig. 7 the pipe 2 has finally been turned to its

vertical position ready to be unloaded from the carrier 6.

[0091] Fig. 8 shows the carrier 6 seen in perspective from behind when the pipe 2 in its vertical position. The pipe is shown in dotted line. However, the supply vessel 3 has due to heavy sea in this situation heeled over an angle in relation to a horizontal plane implying that the carrier 6 forms the same angle with the horizontal plane.

[0092] The pipe 2 is nevertheless maintained in its vertical position owing to the fact that the slewing bearing 21,22 between the seat 16 and the cradle 19, shown in dotted line, has allowed the seat 16 to rotate the same angle in relation to the cradle 16 on the carrier 6 as the supply vessel 3 has heeled over in relation to the horizontal plane into the opposite direction.

[0093] Once the pipe has reached the vertical position, as seen in fig. 7 and 8, the hydraulic cylinders 33 starts to unload the pipe in e.g. steps of 25 tons, preferable automatically.

[0094] The unloading normally takes place at e.g. a rate of 1 - 5 minutes per ton, thereby enabling the supply vessel to perform the necessary ballasting and simultaneously ensuring that the passing over of the full weight of the pipe to the floating crane is executed in a controlled manner.

[0095] The hydraulic cylinders 33 are retracted when the carrier 6 has been unloaded down to a residual of e.g. 50 tons after which the pipe 2 is carried completely by the floating crane 4. The retraction of the hydraulic cylinders 33 takes place at a speed higher than the resultant of the speed by which the crane 4 is lifting the pipe 2 and the supply vessel 3 is moving up and down in the sea for thereby avoiding reloading of the pipe 2 or impact between the pipe 2 and the seat 16 of the carrier 6.

[0096] The hydraulic cylinders 33 are retracted when the carrier 6 has been unloaded down to a residual of e.g. 50 tons after which the pipe 2 is carried completely by the floating crane 4.

[0097] The second set of hydraulic cylinders 35 acting between the protruding arm 36 fixed on each slide 24 and the moment arm 37 fixed on each cradle 19 is at this stage, where the seat 16 is not any longer loaded by the pipe, separately activated so that the cradle 19 with the seat 16 is kept at least in balance. When the carrier 6 has been lowered beneath the pipe 2 hanging in the crane 4, the cradle 19 with the seat 16 is tilted back to the horizontal position for thereby enabling the carrier 6 to pass unhindered below the pipe 2 when the crane 4 leaves the moon pool of the floating crane.

[0098] The invention is by way of example above described and in the drawing shown as a turning arrangement for turning a foundation pile in form of a pipe to an offshore windmill (not shown).

[0099] The turning arrangement of the invention can however within the scope of the invention be used for turning other elongated elements as e.g. massive foundation piles and both at sea and on land.

[0100] Modifications and combinations of the above principles and designs are foreseen within the scope of the present invention.

Claims

1. A turning arrangement for turning an elongated element (2) from a position where the elongated element forms one angle with a horizontal plane to another position where the elongated element (2) forms a larger angle with the horizontal plane, **characterized in that** the turning arrangement (1) comprises,

   - a crane (4) with a first support means (11) for during the turning operation lifting a first end (12) of the elongated element (2), and
   - a carrier (6) with a second support means (6) for simultaneously with lifting the first end, moving the second end (5) of the elongated element (2) towards the crane (4).

2. A turning arrangement according to claim 1, **characterized in that** said first and second support means (8;6) are the only support means of the turning arrangement for supporting the elongated element (2).

3. A turning arrangement according to any of the claims 1, 2 or 3, **characterized in that** the turning arrangement comprises a supply vessel (3) for transporting the carrier (6) and the elongated element (2) up to the crane (4).

4. A turning arrangement according to claim 3, **characterized in that** the supply vessel (3) is equipped with at least one elevating device for elevating the elongated element (2) loaded on the carrier (6).

5. A turning arrangement according to any of the preceding claims 1 - 4, **characterized in that** the crane (4) is a floating crane (4) at sea.

6. A turning arrangement according to any of the preceding claims 1 - 5, **characterized in that** the first support means (11) of the crane (4) comprises a clamp attached to the free end of a wire rope of a winch of the crane (4) for releasable clamping the first end (12) of the elongated element (2) to the wire rope during the turning operation.

7. A turning arrangement according to any of the preceding claims 1 - 6, **characterized in that** the second support means (6) comprises a seat which is releasable mounted on the carrier (6) and is formed with a contact face upon which the second end of the elongated element (2) is resting during the turning operation.

8. A turning arrangement according to any of the pre-

ceding claims 1 - 7, **characterized in that** the second end of the elongated element (2) is secured, at least into the longitudinal direction of the elongated element (2), to the contact face of the seat by means of frictional forces only.

9. A turning arrangement according to any of the preceding claims 1 - 8, **characterized in that** the carrier (6) is equipped with wheels adapted to run upon rails on the deck of the supply vessel (3), which rails are extending into the direction of the crane (4) during the turning operation.

10. A turning arrangement according to any of the preceding claims 1 - 9, **characterized in that** the running resistance which the carrier (6) is meeting while running on the rails during the turning operation is lesser than the frictional forces needed for simultaneously securing the second end of the elongated element (2) to the contact face of the seat of the carrier (6).

11. A turning arrangement according to any of the preceding claims 7 - 10, **characterized in that** the seat is mounted on the carrier (6) pivotally about an axis extending crosswise the axis of the elongated element (2) being in turning position on the seat.

12. A turning arrangement according to any of the preceding claims 7 - 11, **characterized in that** the seat is mounted on a cradle and that the cradle is mounted on the carrier (6) pivotally about an axis extending crosswise the axis of the elongated element (2) being in turning position on the seat.

13. A turning arrangement according to claim 12, **characterized in that** the seat and the cradle is connected by means of a slewing bearing.

14. A turning arrangement according to claim 12 or 13, **characterized in that** the turning arrangement comprises

- an upstanding guideway provided at each side of the carrier (6),
- a slide movably placed in each guideway, and
- the cradle is pivotally suspended on the slides of each guideway by means of axle journals.

15. A turning arrangement according to claim 14, **characterized in that** each slide is formed like an inverted U with a crossbeam extending into the moving direction of the carrier (6) and two legs descending from the crossbeam.

16. A turning arrangement according to any of the claims 14 or 15, **characterized in that** each guideway comprises at least one upstanding rail and that the legs of each slide is equipped with wheels adapted to run along the upstanding rails on the same side as the slide.

17. A turning arrangement according to any of the claims 15 or 16, **characterized in that** at least one hydraulic cylinder is acting between the carrier (6) and the crossbeam of the slide at each side of the carrier (6).

18. A turning arrangement according to any of the claim 17, **characterized in that** the stroke of the piston rod of each of the hydraulic cylinders is controlled in dependence of the motions of the sea.

19. A turning arrangement according to any of the preceding claims 3 - 18, **characterized in that** the turning arrangement comprises means for ballasting the supply vessel (3) in dependence of the unloading of the vessel from the carrier (6) on the vessel (3).

20. A turning arrangement according to any of the preceding claims 17, 18 or 19, **characterized in that** at least one separate hydraulic cylinder is pivotally mounted on the slide of each guideway of the carrier (6) and that the piston rod of said at least one cylinder is connected to a lever arm on the axle journal connecting the cradle to the slide.

21. A method for by means of the turning arrangement according to any of the preceding claims 1 - 20 turning an elongated element (2) from a position where the elongated element (2) forms one angle with a horizontal plane to another position where the elongated element (2) forms a larger angle with the horizontal plane, **characterized in that** the method comprises the steps of,

- laying the elongated element (2) upon a support, which forms one angle with the horizontal plane,
- connecting a first end (12) of the elongated element (2) to a crane (4),
- placing the second end of the elongated element (2) on a carrier (6) adapted to move on the support towards the crane (4), and
- lifting the first end (12) of the elongated element (2) by means of the crane (4) while the elongated element (2) itself simultaneously is dragging the carrier (6) with the second end of the elongated element (2) towards the crane (4) until the elongated element (2) arrives to a position forming another angle with a horizontal plane.

22. A method according to claim 21, **characterized in that** the method comprises the steps of,

- positioning a floating crane (4) on the position at sea where the elongated element (2) is to be

placed,
- shipping the elongated element (2) on a supply vessel (3) in a horizontal position to the position of a floating crane (4),
- releasable fixing a clamp attached to the free end of a wire rope of a winch of the crane (4) to the first end (12) of the elongated element (2),
- releasable fixing the second end of the elongated element (2) to a pivotable support of the carrier (6), and
- activating the winch of the crane (4).

23. A method according to any of the claims 21 or 22, **characterized in that** the method comprises that a foundation pile for an offshore windmill is turned from a horizontal to a vertical position.

24. A method according to any of the claims 21, 22 or 23, **characterized in** stepwise retracting the hydraulic cylinders (33) acting between the carrier (6) and the slides (24) when the elongated element has been turned to its vertical position while at the same time ballasting the supply vessel (3).

25. A use of the turning arrangement according to claims 1 - 20 for turning a elongated element from a horizontal to a vertical position.

26. A use according to claim 25, wherein the elongated element is a foundation pile for an offshore windmill.

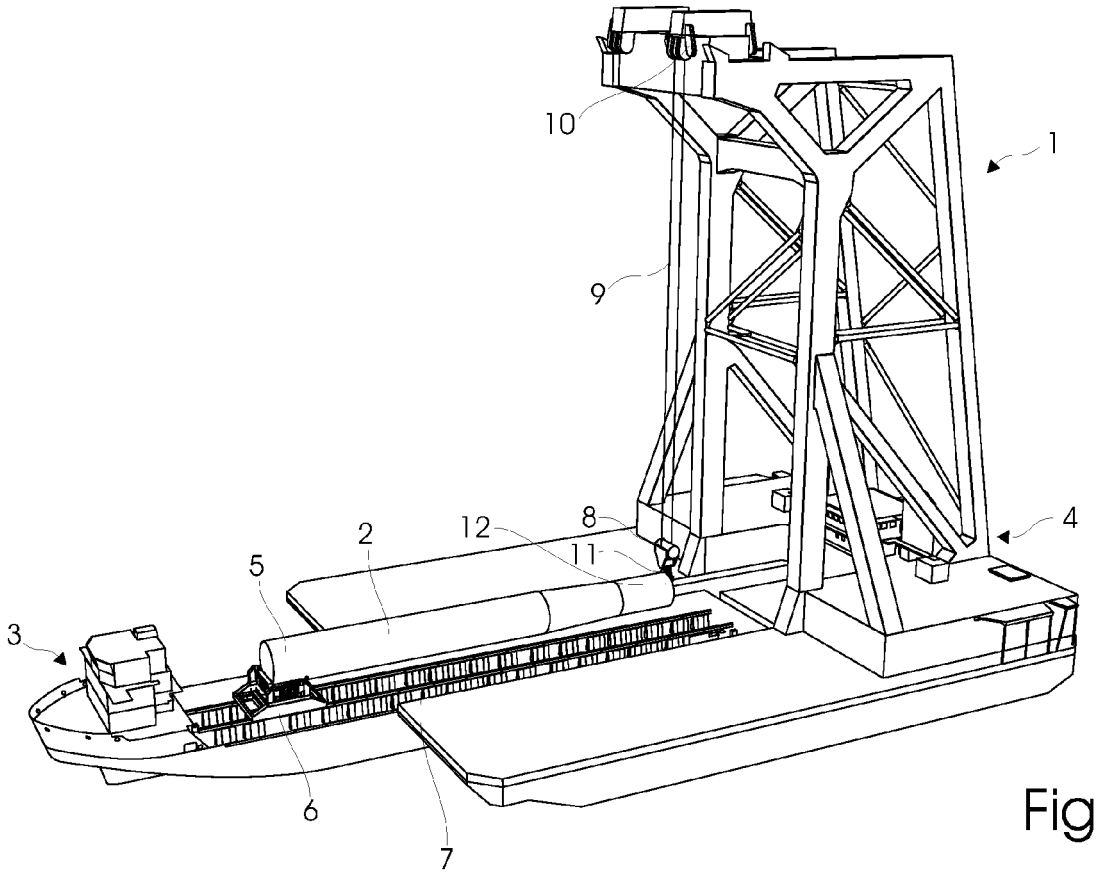


Fig 1

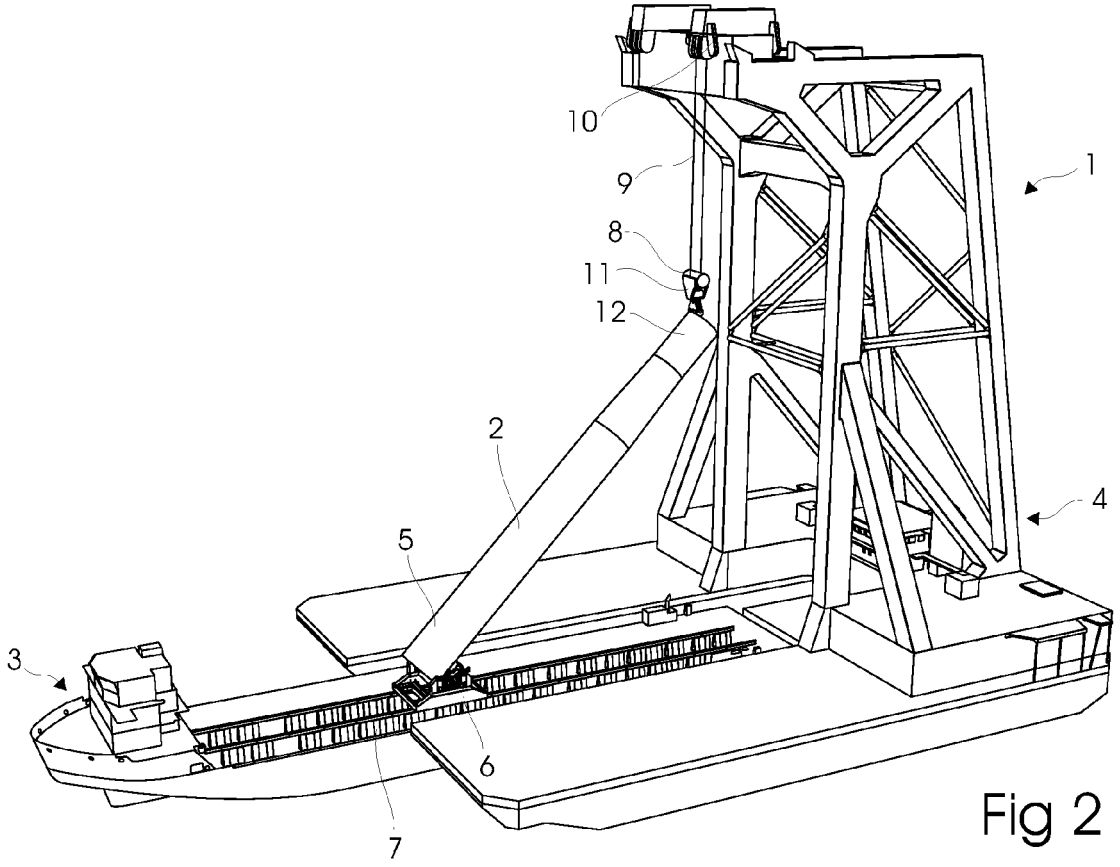


Fig 2

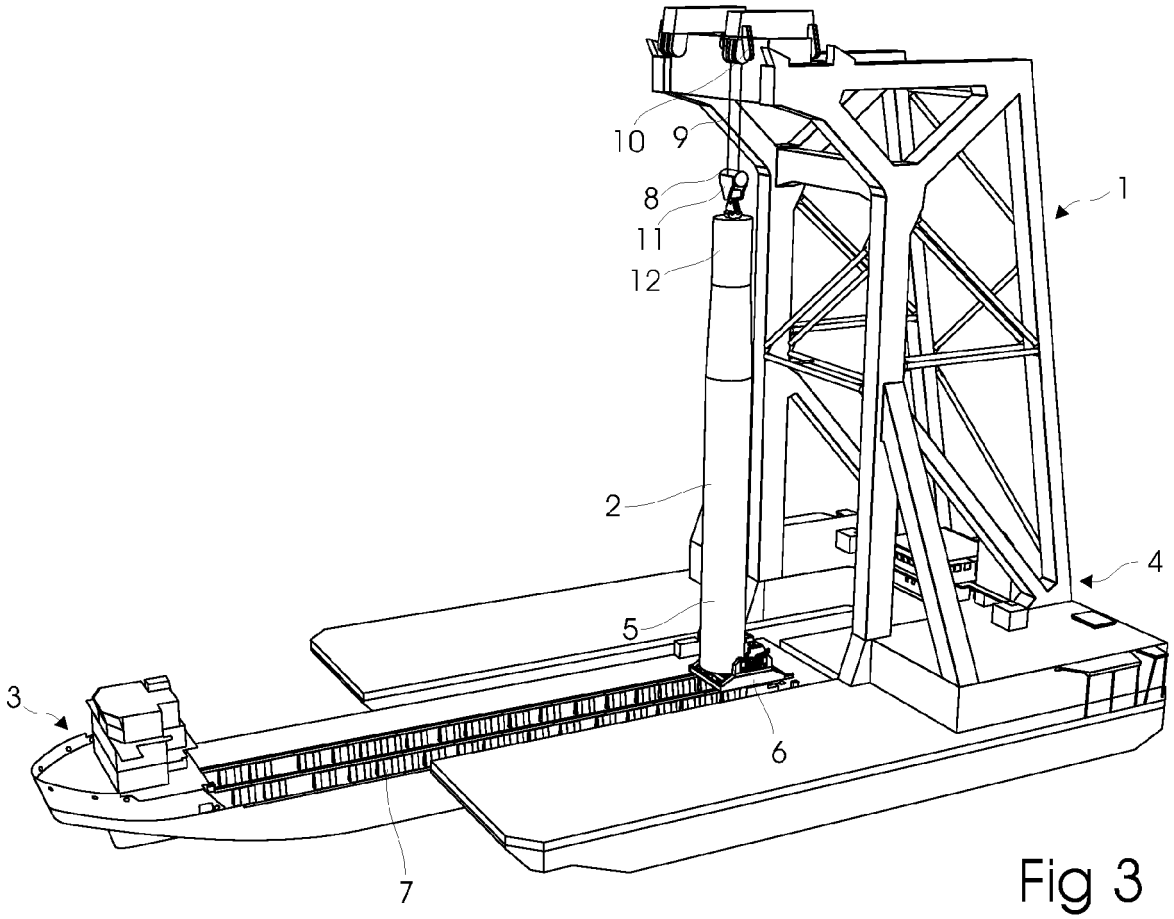


Fig 3

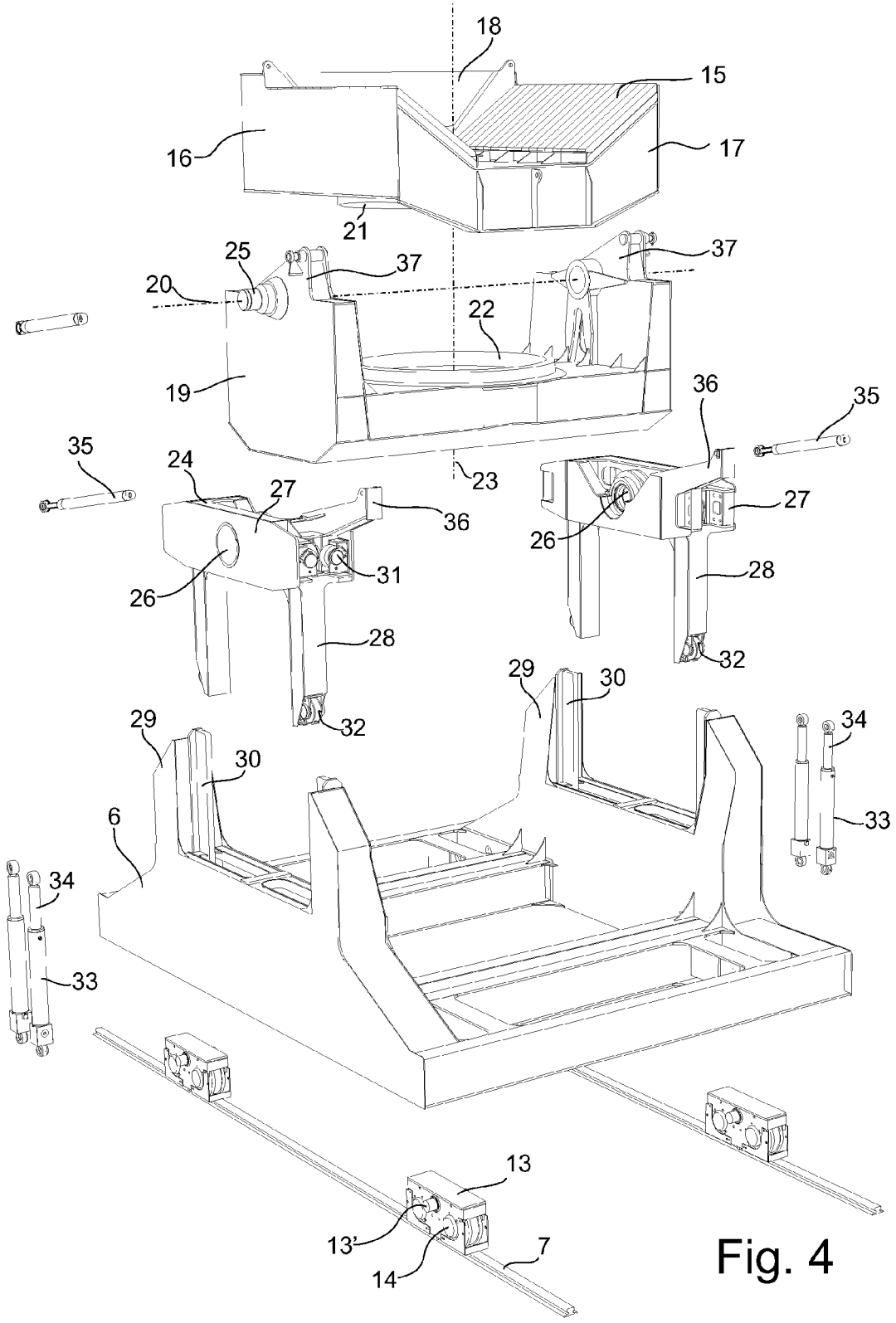

18
15
16
17
21
25
37
37
20
22
19
36
35
35
24
27
27
36
26
31
26
28
28
32
32
29
30
29
30
34
6
34
33
33
13
13'
14
7

Fig. 4

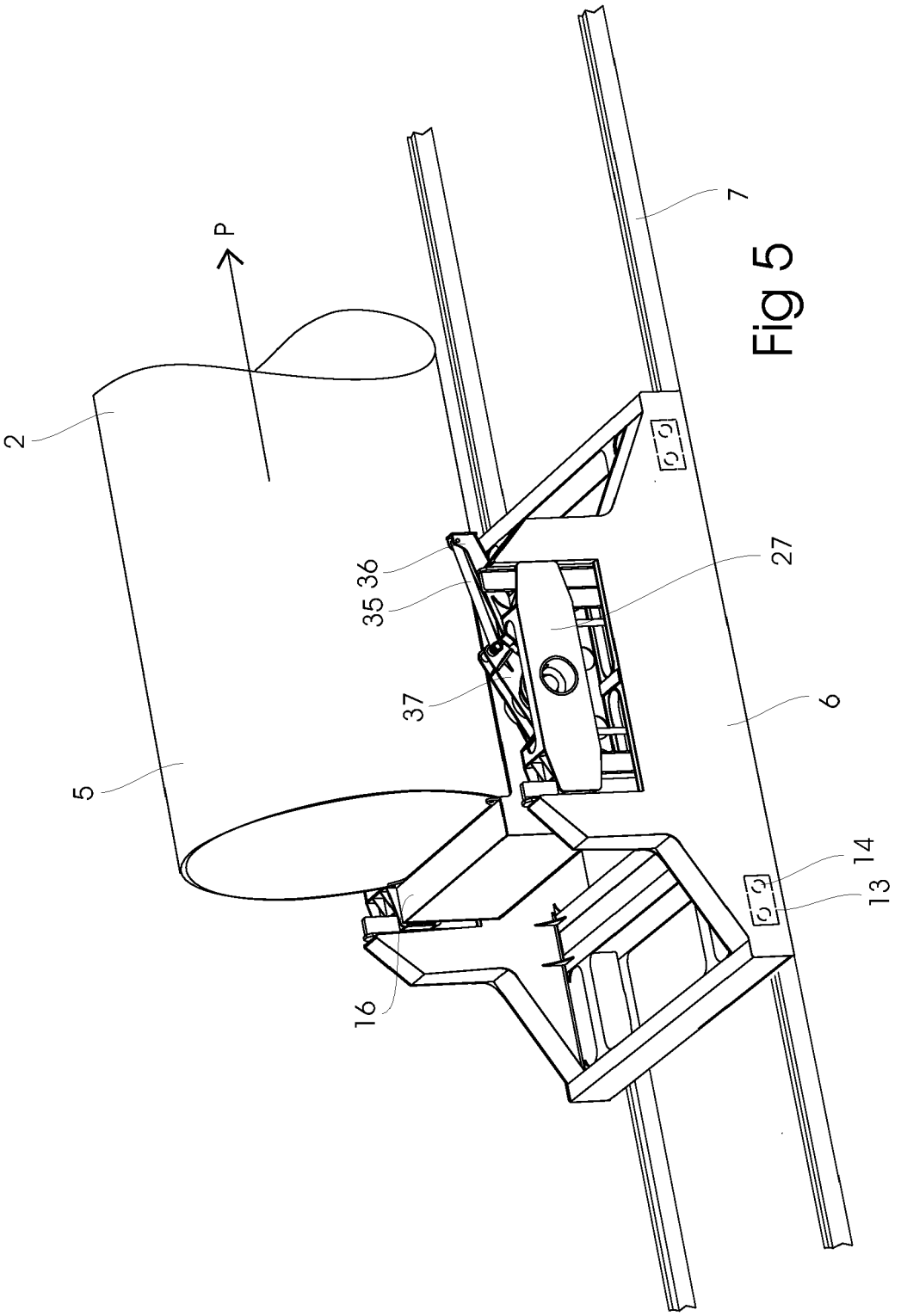


Fig 5

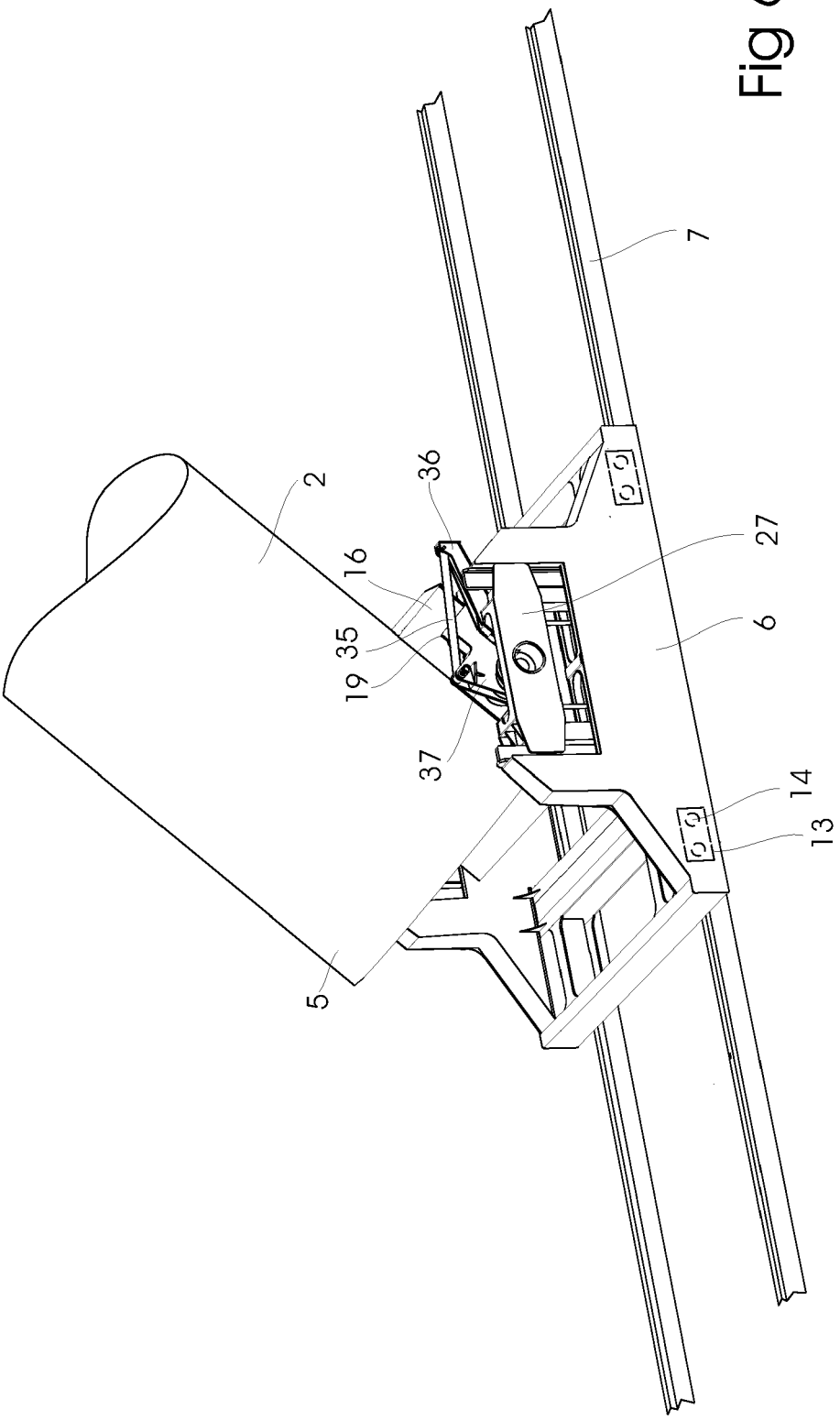
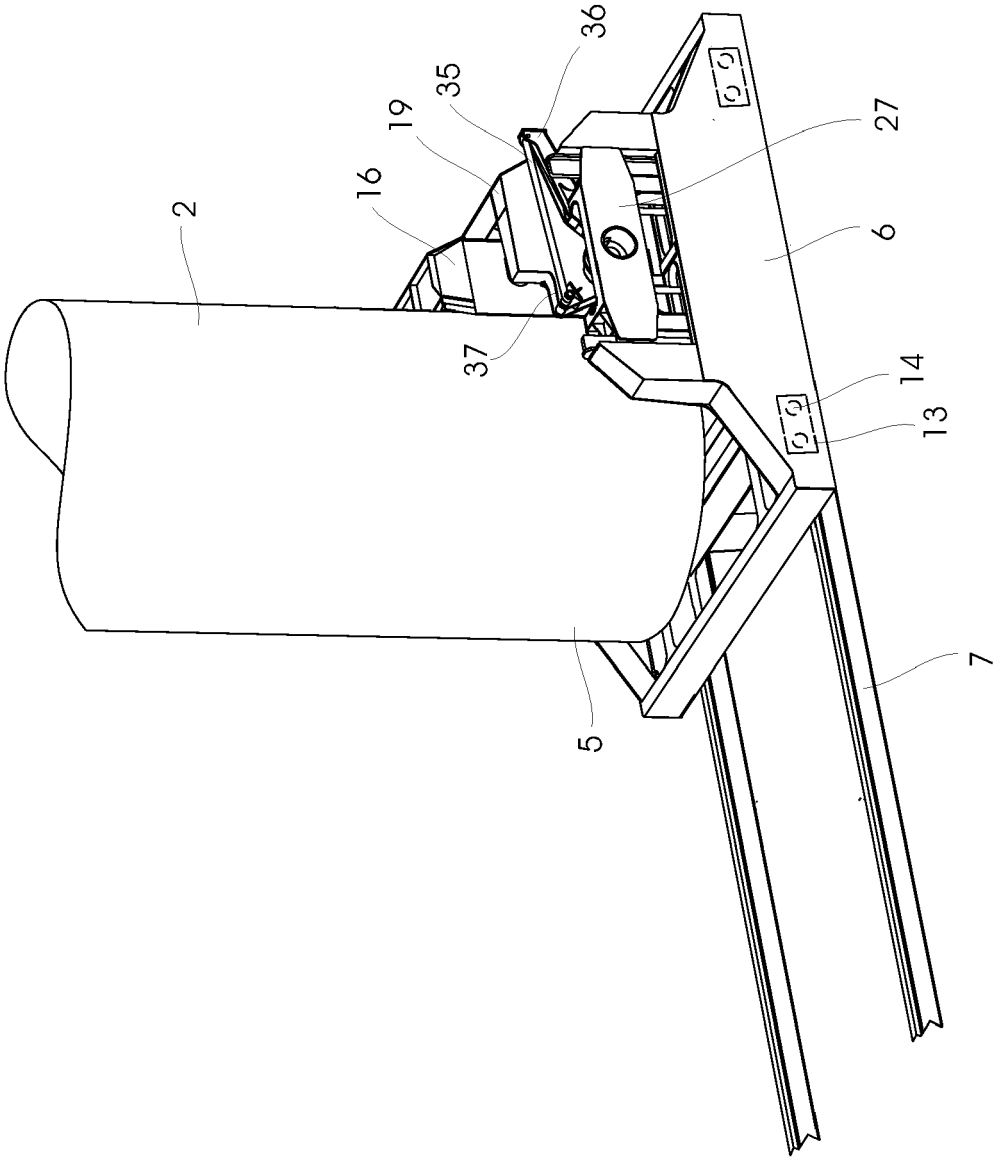


Fig 6

Fig 7



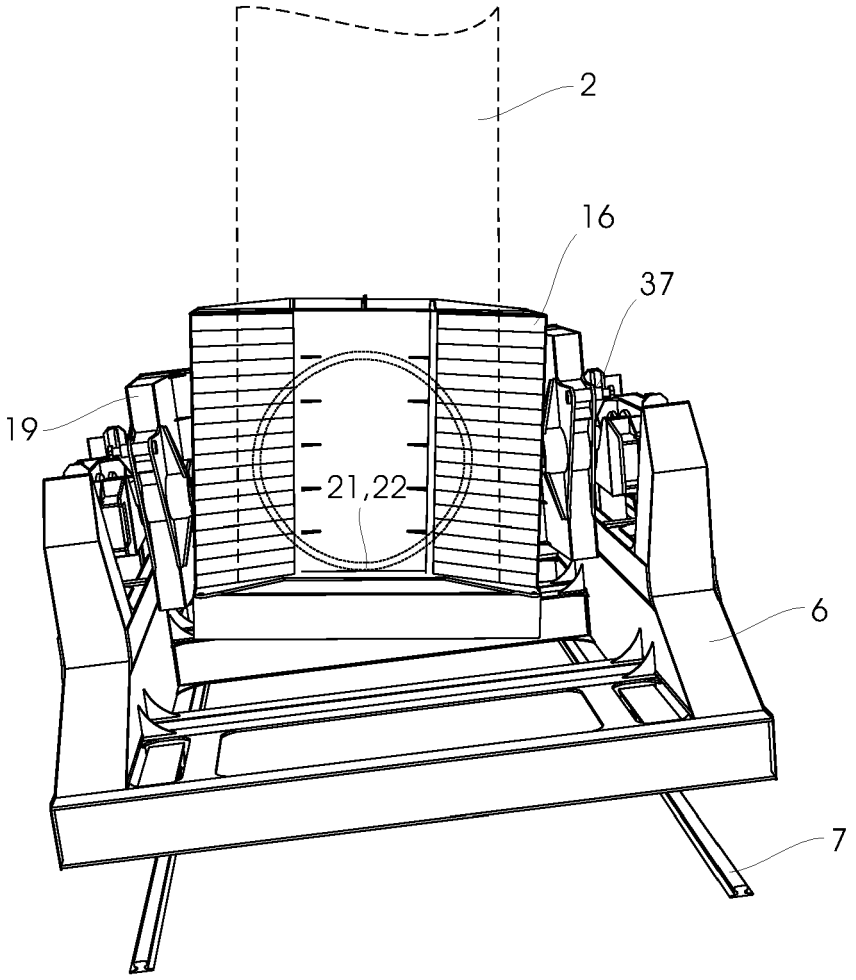


Fig 8

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 10 15 4566

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 5 375 667 A (TREVISANI DAVIDE [IT]) 27 December 1994 (1994-12-27) * column 2, line 9 - line 23; figures 2,3 * * column 2, line 46 - line 68 * -----	1,2,7,8, 21,25	INV. E02B17/04 E21B19/00
A,D	GB 2 137 261 A (TOTAL TRANSPORTATION; MOSS ROSENBERG VERFT AS) 3 October 1984 (1984-10-03) * the whole document * -----	1	

TECHNICAL FIELDS SEARCHED (IPC)

E02B
E21B
B66C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	19 August 2010	Flygare, Esa

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 10 15 4566

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

19-08-2010

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5375667 A	27-12-1994	DE 69229748 D1	09-09-1999
		DE 69229748 T2	23-03-2000
		ES 2136342 T3	16-11-1999
		IT 227642 Y1	15-12-1997
GB 2137261 A	03-10-1984	NO 831115 A	01-10-1984

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- GB 2137261 A **[0004] [0019]**

Non-patent literature cited in the description

- **HUGH BROOKS.** Illustrated Encyclopedic Dictionary of Building and Construction Terms. Prentice Hall, 1976 **[0023]**