

Title: Azimuth Friction free Towing point

The present disclosure relates to a tug boat intended for use in harbour and/or at sea, including at least a towing winch. A tug boat is intended to assist a vessel at relatively slow speed while harbour towing. A first end of a towing cable is connected to a towing winch. The towing cable is
5 guided through a towing point and connected to the vessel being assisted, establishing an effective towing cable connection able to sustain a significant pulling force on the assisted vessel, thus improving the manoeuvrability of said vessel. A tug boat at sea is generally limited to operating in this manner due to adverse operating conditions at sea compared to use in a harbour.

10 The art distinguishes two major towing modes, namely the pulling- and pushing mode. In pulling mode a tug boat generates a pulling force on a towing cable connection, resulting in a force on the assisted vessel. In pushing mode a tug boat exerts a pushing force on an assisted vessel through a pushing point located at either a tug boats front, stern or side. It is common business
15 practice to apply a means of protection at such pushing points to prevent damages to the assisted vessel and tug boat while operating in pushing mode. Furthermore combinations of both pulling- and pushing mode are known within the art wherein both pulling- and pushing forces are exerted simultaneously on the assisted vessel and by the same tug boat.

20 A tug boat should be able to operate in preferably all conceivable directions and preferably all conceivable operating conditions. Furthermore, a harbour tug boat is required to apply maximum pushing and pulling power on its towing point and/or pushing point also in preferably all directions and operating conditions. In view of such requirements, a towing point may in fact
25 be used an azimuthal towing point and a propulsion unit commonly used in current tug boats can be, in fact, a propulsion unit capable of delivering great

propulsive thrust in all directions. Azimuthal herein at least meaning a range exceeding 200 degrees, more specifically exceeding 270.

A towing cable connection is usually established by guiding a towing cable from an assisted vessel through a towing point apparatus to a towing winch. Said towing point apparatus can consist of a fixed towing bitt, towing staples or fairlead or any combination thereof. Fixed towing bitts and staples are generally constructed from round- or oval-type cylinders and are usually limited in the direction of applying pulling forces by their towing point designs extending roughly in a 180 degree arc from said towing point.

A tug boat operates in close proximity of an assisted vessel during for example mooring and unmooring operations. In pushing mode and more specifically in heavy seas with significant movement of a tug boat compared to the assisted vessel, there is an increased risk of damage to the tug boat, assisted vessel or both. Protective measures are commonly applied to a tug boat's hull partly mitigating risk of damage in favourable operating conditions.

In pulling mode, the close proximity and the geometry of an assisted vessel result in that said towing cable connections operate at relative high angles up to 60 degrees to a horizontal plane at the towing point. In case of significant movement of a tug boat compared to the assisted vessel, caused for example by heavy seas, the dynamic pulling forces acting on the towing cable connection can easily exceed safe working loads of bollards on the assisted vessel, the towing cable or both. More specifically said dynamic pulling forces can result in failure of a bollard and/or towing cable and thus result in failure of the towing cable connection.

A towing winch can be capable of rendering and recovering a towing cable such that a constant pulling force is maintained on the towing cable connection automatically. More specifically said towing winches can be able to maintain a constant pulling force on a towing cable connection despite significant movements of a tug boat compared to the assisted vessel. Thus such a towing winch can enable a tug boat to operate in pulling mode in a maximum

number of working conditions compared to historical towing winches without risk of failure of the towing cable connection or any part thereof by for example snag loads in a towing cable connection. Such a towing winch is herein referred to as a render and recovery winch or constant tension winch.

5 Historically, existing towing point apparatus in combination with a render and recovery towing winch result in significant chafing and friction between a towing cable and the towing point apparatus. Said chafing and the friction there from increases wear and tear of said towing cable and/or the towing point apparatus, thus significantly reducing the estimated time to
10 failure and operational lifespan of either towing cable or towing point apparatus or both. Furthermore said friction increases temperatures inside said towing cable. Especially synthetic fibre towing cables have a limited maximum safe working temperature which may easily be exceeded by such friction.

15 The art recognizes a variety of materials and configurations to manufacture effective towing cables. Historically towing cables include but are not limited to steel wire ropes. Furthermore towing cables can also be made from synthetic materials, including but not limited to, for example UHMWPE (Ultra High Molecular Weight Polyethylene) or Dyneema towing cables.
20 UHMWPE is a synthetic fibre capable of sustaining the significant pulling forces on a towing cable connection with Dyneema being a specific brand of UHMWPE fibre materials. Synthetic materials such as UHMWPE's main advantage for the towing cable application is weight. For example, UHMWPE weighs approximately 14 percent of an equivalent steel wire towing cable.
25 Thus an UHMWPE towing cable is substantially easier to handle by a tug boats crew. The UHMWPE towing cable floats on water due to its lightweight characteristics with a decreased risk of the towing cable getting entangled in for example propellers. A major disadvantage of an UHMWPE towing cable can be its maximum safe working temperature of approximately 65 degrees
30 Celsius maximum.

In view of the advantages of a render and recovery towing winch and synthetic towing cables, a tug boat is ideally equipped with a combination of both types of equipment. However with existing towing point designs the mean time to failure of a towing cable connection is significantly reduced due to the previously referred chafing issues for towing cables. These chafing issues significantly increase repair, maintenance and replacement costs for a tug boat's towing cables or towing points depending on the type of towing cable.

Generally a purpose of the present disclosure can be to provide a tug boat with an improved ability to exert pulling forces on a towing cable connection in preferably all directions. In particular a purpose of the present disclosure can be to enable the ability for a tug boat to exert a significant pulling force on a towing cable connection in an as large as possible arc, as close as possible to, for example between 270 and 360 degrees or more around a towing point. A purpose of the present disclosure can be to establish such a towing cable connection in a safe manner, also in case a tug boat operates in very close proximity to a vessel and/or in adverse sea states and/or weather conditions.

The present disclosure embodies a movable towing point apparatus. Said movable towing point apparatus can guide a towing cable from an assisted vessel preferably through a guiding apparatus which in turn guides the towing cable onto a freely pivoting element. From said element the towing cable is guided onto a winch, preferably a render and recovery winch. Said element can pivot around its centre axis and can pivot over an arm on an axis non-parallel and preferably perpendicular to said centre axis.

Said guiding apparatus can be situated at or near the end of an arm which in turn can pivot around said . Said guiding apparatus axis and can guide the towing cable onto said rotating element in a substantially friction free manner by means of repositioning the arm supporting said element.

In view of a tug boats requirements to apply power on its towing point or towing points in preferably all conceivable directions and in preferably

all conceivable working conditions an azimuthal towing point apparatus is strongly preferred over existing towing point apparatus. A combination of an azimuthal towing point apparatus and a render and recovery towing winch may be preferred in order to maintain a constant pulling force on a towing
5 cable connection, maximizing control of the assisted vessel's movements while operating in pulling mode or pulling mode and pushing mode enabling safe operation in close proximity to an assisted vessel.

The present disclosure enables the successful application of an azimuthal friction free towing point apparatus. Said towing point apparatus
10 minimizes friction between a towing cable and towing point, significantly reducing heat generated from said friction. The present disclosure thus enables the application of synthetic fibre towing cables subject to limited safe working temperatures or significantly reduces chafing on steel wire towing cables. More specifically the present disclosure successfully enables the use of
15 towing cables of any type and material in combination with render and recovery towing winches.

The present disclosure enables a tug boat to apply a pulling force over an increased range of conceivable directions and a maximum conceivable operating conditions as opposed to existing towing point designs. More
20 specifically this means that a tug boat equipped with a towing point according to the present disclosure can assist vessels during adverse weather conditions and related sea states or in working areas with high outdoor temperatures in excess of for example 35 or 40 degrees Celsius.

Another advantage of the present disclosure can be that a tug boat
25 can remain in pulling mode during the entire mooring operation of an assisted vessel. Historical mooring operations recognize a limited timeframe when switching between pulling and pushing mode wherein a tug boat is not able to exert either a pulling or pushing force. In order to regain full control of an assisted vessel an increased pushing force is usually required. Alternatively a
30 tug boat operator can use additional tug boats operating in pulling and

pushing mode. Hence another advantage of the present disclosure is that it allows for a much more efficient and flexible deployment of tug boats during mooring and unmooring operations while retaining full control over an assisted vessel.

5 Yet another advantage of the present disclosure can be that due to the increased control over a vessel, the present disclosure reduces risk of damage to a tug boat and/or vessel during berthing operations. Especially in case of vessels carrying dangerous or volatile goods like for example LNG carriers or chemical carriers such reduction of risk of damage is important.

10 Yet another possible advantage of the present disclosure relates to towing operations at sea. In the modern day long steel wire towing cables are used to accommodate for ship movements. These long steel wire towing cables can be as long as 1.5 kilometres or greater. The distance between a vessel or object under tow and tugboat results in all manners of navigational risks with
15 other vessels sailing across the towing cable and damaging the towing cable connection or the towing cable can get entangled in wreckages resting on the sea floor. The present disclosure can significantly mitigate said navigational risks by reducing the distance between a tugboat and towed vessel or object considerably, even as much as to a 200 meter or even smaller. Furthermore
20 the present disclosure reduces weight for a tugboats towing system when equipped for sea-going operations due to a shorter towing cable requirement.

In view of the above, according to a first aspect, there is provided a tug boat having at least one towing winch and a movable towing point apparatus, wherein said towing point apparatus can guide a towing cable from
25 a towing winch to a vessel to be assisted, comprising a rotating element that at least partly guides the towing cable such that the pulling force on said cable is transmitted to the tug boat at least partly through said rotating element when in use, said rotating element pivoting freely around a first axis and said first axis fixed to an arm which in turn can pivot about a second axis, said second

axis being spaced apart from said first axis and the second and first axis being non-parallel.

According to a second aspect, there is provided a movable towing point apparatus for use in a tugboat as described above.

5 According to a third aspect, there is provided a method for assisting a vessel by a tug boat by connecting a towing cable between a winch on the tug boat and the vessel, wherein on the tugboat the towing cable is guided by a movable towing point, such that the position of the towing point is adjusted relative to the tugboat depending on the position of the vessel relative to the
10 tug boat, wherein the towing cable is guided by and/or over the towing point substantially friction free.

 According to a fourth aspect, there is provided a method for assisting a vessel with a tug boat, by connecting a towing cable between a winch on the tug boat and the vessel, wherein on the tugboat the towing cable is guided by a
15 movable towing point, and wherein the position of the towing point is adjusted relative to the tugboat depending on the position of the vessel relative to the tug boat, wherein the towing cable is guided over a rotating element such as a roll or wheel of the towing point or forming the towing point, which rotating element is rotated on an axis which is moved relative the tug boat.

20 Embodiments of the present invention shall be described, with reference to the drawings, for elucidation of the invention. These embodiments should by no means be understood as limiting the scope of the invention in any way or form. In these drawings:

 Figure 1 is a schematic longitudinal view of a tug boat, to illustrate
25 the possible position of a tug boats towing points, towing winch and pushing points.

 Figure 2a-b illustrates the two major harbour towing modes for tug boat 1

Figure 3a illustrates a mooring operation for vessel V.

Figure 3b illustrates another mooring operation for vessel V.

Figure 3c illustrates the reduced movement when switching
direction of power applied to vessel V compared to the mooring operation
5 illustrated in figure 3a.

Figure 4a illustrates a towing operation at sea according to the prior
art.

Figure 4b illustrates a towing operation at sea according to the
present disclosure.

10 Figure 5 illustrates an embodiment of the present disclosure.

Figure 6 illustrates another embodiment of the present disclosure.

Figure 7a-b illustrates two possible guiding apparatus for a towing
cable according to the present disclosure.

Figure 8a-c illustrates a top and side view of an embodiment of the
15 present disclosure.

In this description exemplary embodiments of a tug boat and towing
point of the present disclosure are shown, by way of example only. These
should by no means be considered as limiting the scope of the present
disclosure. The drawings are schematic only. In these drawings the same or
20 similar reference signs shall be used for the same or similar parts or features.

In this description vertical and horizontal are referred to as planes
or directions in their ordinary meaning, whereas directions related to the
vessel or tug boat defined by horizontally or vertically are taken when the
vessel or boat is in a position afloat, in a normal, stabilized position, unless
25 specifically otherwise defined.

In this description substantially friction free has to be understood as
including but not limited to friction substantially lower than the friction in
towing cables and towing points in known towing operations for the same
vessel and tug boat. Substantially friction free can be understood as
30 comparable to a cable guided straight over a freely rotating roll or wheel, such

that a substantial roll-off movement occurs between the guiding element such as a roll or wheel and cable in a direction parallel to a longitudinal direction of the cable.

In this description rotating freely or pivoting freely or words to that effect can be understood as meaning that no significant resistance against rotating or pivoting of the element is provided, at least during use of the towing point. This can be understood as meaning that during normal operations slip between the cable and the rotating element is avoided.

In general terms a tugboat and method according to the description allows the towing point to follow changes of the position of a vessel assisted by a tugboat relative to the tugboat, such that a cable used in such assistance is guided by a roll or wheel or such rotating element rotating around an axis, such that the cable extends substantially in a plane perpendicular to said axis, irrespective of the position of the vessel relative to the tug boat.

In preferred embodiments the cable is guided at least at a side of the rotating element facing away from the winch on the tugboat, and preferably also at a side of the element facing the winch. The guiding of the cable is preferably such that any movement of a part of the cable out of the said plane substantially perpendicular to said axis or rotation of the element will lead to a repositioning of the element such that the cable is again brought back towards and preferably into said plane.

Figure 1 schematically shows the contour of a tug boat 1 viewed from the side, with a number of possible towing positions 2 and pushing positions 3. A towing point 2 is defined hereinafter as the last physical point on tug boat 1 that fairleads a towing cable 4 from a towing winch 5 to a vessel V being assisted, establishing a towing cable connection 6 between tug boat 1 and assisted vessel V capable of sustaining significant pulling forces. A pushing point 3 is defined hereinafter as the last point of physical contact between tugboat 1 and vessel V. Herein a contact point is to be understood as also including a line contact or area of contact preferably relatively small

compared to the sizes of the tugboat 1 and vessel V. With respect to towing point 2, the towing cable 4 can at least for example turn sideways through 90° or more in a horizontal plane towards both sides of a mid position, which can for example be parallel to or can be in a vertical mid sectional, longitudinal
5 plane P (fig. 8) of the tug boat 1. A towing point 2 can either be a fixed or moving apparatus hereinafter defined as a towing point apparatus 2 as per the present disclosure. Other moving towing point apparatus are known within the art for example US 6,698,374 and US 5,609,120. In a design of US 5,609,120 a towing cable is guided by a guide in a plane parallel to the deck
10 of a tug boat only and only over about 90° to both sides from the mid position. Chafing and friction will still occur. Even more specifically some moving towing point apparatus like for example US 6,698,374 allow for the towing cable 4 to turn sideways through 360° towards both sides. This design is however very complicated and requires a special design for a cabin, which has
15 limited access. Moreover, friction and chafing still occur between cable and the towing eyelet. By using towing winch 5, the cable length can be adapted to the desired towing length and manoeuvring distance. On historical tug boats, there is only a winch and towing point at the stern; in many modern tug boats, a towing point 2 and towing winch 5 are arranged on both front and stern.
20 Historically with towing winches, the towing cable length can be adapted to the desired towing length and manoeuvring distance only. Render and recovery towing winches are able to apply and/or maintain a constant pulling force on a towing cable connection 6 in case tug boat 1 or vessel V move relative to each other due to for example heavy seas. Said towing winches are
25 also known as render & recovery, rend & receive or constant tension winches either term being interchangeable with the other for purposes of the present disclosure.

Figure 2a-b illustrates the two major harbour towing modes for tug boat 1 namely pulling- and pushing mode. During pulling mode (fig. 2a), tug
30 boat 1 applies a pulling force 7 on a towing cable connection 6. During pushing

mode (fig. 2b), tug boat 1 directly applies a pushing force 8 on vessel V. The pulling mode is most commonly used to position a vessel close to its respective berth. A combination of pulling- or pushing mode with multiple tug boats is commonly used during final mooring operations of vessel V.

5 During operations in pushing mode, where a pushing point 3 can apply a pushing force 8 on vessel V said pushing point 3 can shift as much as 9 meters horizontally and 7 meters vertically during adverse operating conditions. More specifically said operating conditions include adverse sea states up to 3m or more significant wave height. Said shifting of a pushing
10 point 3 across vessel V's outer plating and application of a pushing force 8 results in significant friction forces between a pushing point 3 and vessel V.

 It is obvious for people skilled in the art that a large area wherein said pushing force 8 is applied to vessel V's outer plating contains an increased risk for damage to said plating and thus vessel V. Equally said friction can
15 result in damages to tug boat's 1 pushing point 3 which is cumbersome and costly. It is common business practice to apply protective measures or fendering systems to possible pushing points 3. It is both costly and time consuming to repair damages to pushing points 3 and/or vessel V. Furthermore and especially in case of vessel V carrying dangerous goods, damages to the
20 outer plating can have significant and adverse environmental effects to for example a ports surrounding eco-system and safety.

 Figure 3a illustrates a historical mooring operation for vessel V. It displays a number of tug boats a, b, c and d berthing vessel V in a direction Vs. The pilot of Vessel V can order more or less tug boats to assist vessel V
25 depending on operating conditions at the time of berthing. Historically a mooring operation can consist of either 2, 3, 4 or greater number of tug boats. Figure 3a illustrates four tug boats, tug boat a and d operate in pulling mode while tug boat b and c operate in pushing mode. In another configuration with only two tug boats a and d assisting vessel V, said tug boats can switch to
30 position of tug boats b and c and switch between pulling and pushing mode

creating a timeframe wherein no control is exerted by said tug boats on vessel V. This is also illustrated in figure 3a. In yet another configuration using three tug boats, tug boats a and d operate in pulling mode with a third tug boat b operating in pushing mode. In yet another configuration tugboats a and b
5 operate in pulling mode in the opposite direction up to distances of 400m, with tugboats c and d operating in pushing mode in accordance with figure 3a.

Figure 3b illustrates a nowadays mooring operation with two tug boats a and b assisting a vessel V in a direction Vs. Figure 3b illustrates tug boats a and b operating in pulling mode. In said mooring operation tug boats a
10 and b remain in pulling mode during the entire mooring operation. Only tug boats similar to for example so-called rotortugs (US6,079,346) or ship docking modules (US5,694,877) are capable of executing a mooring operation as illustrated in figure 3b. Furthermore any combination of the mooring operations described in figure 3a-b are also possible. These known tug boats
15 however have the problems and limitations as described in the introduction.

Figure 3c illustrates the turning movement for a tug boat b when changing direction of a pulling force 7 on the towing cable connection 6 during a mooring operation from figure 3b. It is exemplary that the reduced turning movement in figure 3c is a magnitude smaller compared to the turning
20 movement of figure 3a when switching between pushing and pulling mode of said tug boats. Thus when remaining in pulling mode during the complete mooring operation a tug boat can exert a greater amount of control on vessel V.

Figure 4a-b illustrates a sea-going towing operation. Figure 4a illustrates a modern day towing operation with a distance L between tugboat 1
25 and vessel V. Distance L can be as great 1.5 kilometre and distance D can be as great as 200 metre. Distance D is the maximum depth of the cable under the water surface. Such depth D can limit the use of a tugboat in relatively shallow water, such as for example the North Sea. Towing cables' 4 geometry allows for the absorption of relative movements between vessel V and tugboat
30 1 in a towing operation according to figure 4a. Figure 4b illustrates a towing

operation that can be used with the present disclosure. Distance L and D are significantly reduced compared to figure 4a. More specifically distance L can be as short as e.g. 150 metre or less as wherein distance D is reduced to zero. In the present disclosure relative movements between vessel V and tugboat 1 are absorbed by towing winch 5. The present disclosure thus mitigates navigational risks associated with the great distance L and D in modern day sea-going towing operations. More specifically distance L can be reduced up to ten times or even more and distance D is reduced entirely. Even more specifically this also reduces length of towing cable 4, reduces weight, especially but not only significant in case of a steel wire towing cable and or enables the application of UHMWPE towing cables in sea-going towing operations. An additional benefit of the present disclosure can thus be that a harbour operating tugboat 1 equipped with the present disclosure can be used in both harbour towing operations and sea-going towing operations.

Figure 5 illustrates an embodiment of the present disclosure. This embodiment includes a rotating element 9, for example a wheel 9 as illustrated in figure 5-6, pivoting freely around an axis Y-Y. A towing cable 4 is guided along the rotating element 9 to a render and recovery towing winch 5. Said axis Y-Y is attached to an arm 10 which can pivot freely, for example up to 90 degrees or more to either side in a substantially vertical plane, around an axis X-X perpendicular to the view of figure 5. The cable can be any known and/or suitable type, and preferably is at least partly made of steel and/or synthetic materials, for example as discussed before.

Figure 6 illustrates another embodiment of the present disclosure. In this configuration axis X-X is fixed to an element 11 which moves freely over a curve 12, from a substantially vertical position. The curve 12 is e.g. formed by one or more guide rails and extends for example substantially in a horizontal plane and/or substantially parallel to the deck 37 of the tug boat 1. The curve can have a circle-segment configuration with a centre point at an axis Z-Z, between the curve 12 and the winch 5 or at the winch. The curve 12

can include an angle of for example up to or over 180° or 270° degrees. At the axis Z-Z or centre of the curve a further guide can be provided for the cable 4. A guiding apparatus 13, not illustrated in figure 5 or figure 6, but displayed in figure 7, can ensure that the towing cable 4 is continuously guided onto
5 rotating element 9. Furthermore also axis X-X and Z-Z can remain perpendicular to each other at all times. In all embodiments the axis X-X, Y-Y and Z-Z can be either real axis or virtual axis.

Figures 7a-b illustrate a guiding apparatus 13 attached to an arm 14 pivoting freely around axis Y-Y such that guiding apparatus 13 can move along
10 at least part of the circumference of the wheel 9. Figure 7a illustrates said apparatus 13 in a towing eyelet embodiment. Figure 7b illustrates said apparatus 13 in an embodiment containing four roller guides on its far end ensuring a towing cable 4 is guided on rotating element 9 in a friction free manner.

15 Guiding apparatus 13 ensures that arm 10 in either embodiment of the present disclosure is aligned with the towing cable connection 6 such that axis Y-Y is perpendicular to a plane spanned by a towing cable 4 between towing point 2 and towing cable connection 6 and towing winch 5 or between vessel V and axis Z-Z. Said alignment is achieved by a resultant turning
20 moment about axis X-X from pulling force 7, arm 14 and arm 10. Free rotation of element 9 provides an additional degree of freedom in movement of a towing cable connection 6. Guiding apparatus 13 creates a turning moment about axis X-X, without limiting towing cable movement about axis Y-Y. During towing little to no force is exerted on the element 13 other then for repositioning
25 element 9. On a side of the wheel 9 a further guide element 16 can be provided between the wheel 9 and the winch 5, guiding the cable. Below the wheel 9 an additional rotating element 15 can be provided rotating freely around an axis which may extend parallel to the axis Y-Y, for further guiding the cable.

Figure 8a-c illustrates an embodiment of the present disclosure.

30 Figure 8a illustrates a top view on part of a tug boat 1 with an embodiment of

the present disclosure with a towing point 2 in different positions. Figure 8b illustrates a side view of an embodiment of the present disclosure with the various axis A-A, X-X, Y-Y and Z-Z. Figure 8c illustrates a detailed top view and side view of an embodiment of the towing point 2 apparatus according to the present disclosure with further illustrations on the various axis alignments. In general the axis X-X and Y-Y can be spaced apart over a distance T and can extend in a non-parallel manner, for example perpendicular to each other. They can be situated in parallel planes. Arm 10 can have any shape, as long as it connects the second axis X-X and first axis Y-Y directly or indirectly.

In the embodiment of fig. 8 the rotating element 9 is a wheel with flanges 35, rotating on a first axis Y-Y carried on an arm 10 which is pivoting around the second axis X-X. In fig. 8b the towing point 2 is shown in an upright mid position. In this embodiment the second axis X-X extends substantially as a tangent to the lower side of the running surface 30 of the rotating element 9. The second axis X-X is defined by a longitudinal axis of a hollow cylinder 31 rotatable in a support bracket 32 forming part of the element 11. The element 11 can be carried on a rail or such track, which may be straight or bent, or partly straight and partly bent, and can extend generally withwise across at a part of a deck 37 of the tug boat 1. In fig. 8 the track 12 is straight. The arm 10 is hooked, such that the axis Y-Y is positioned spaced apart from the second axis X-X. The bracket 32 is also hooked, such that it can be carried on the track or rail or on a deck 37 by a support 33 defining the axis A-A, preferably in a position below the rotating element 9 when the arm 10 is in said upright position. The axis A-A can for example extend substantially perpendicular to the deck 37, can be substantially vertical and/or can extend substantially perpendicular to the first axis Y-Y. The axis A-A will allow the bracket 32 to pivot around axis A-A when the cable exerts a pulling force on the towing point 2 in a direction out of a plane defined by the axis A-A and X-X. This can especially be useful when the bracket 32 is carried

on a rail or track which is for example straight or bent with a profile other than according to a circle segment around a fixed point or guide unit 34 on the deck 37 through which the cable 4 is led between the rotating element 9 and the winch 5. The axis A-A will allow the towing point apparatus 2 nevertheless
5 be repositioned such that the axis X-X will extend parallel to and preferably coinciding with a straight line between the point of surface 30 of rotating element 9 where the cable leaves the said surface 30 towards the winch 5, which will normally be a radial line between said surface point and the fixed point or guide unit 34 on the deck 37 as mentioned here above. Preferably the
10 axis A-A is position such that it does not coincide with a tangent to the surface 30 parallel to the axis A-A. This may ensure an automatic repositioning of the towing point 2 around axis A-A due to a movement of the pulling force in the cable 4 out of a plane perpendicular to the axis Y-Y and through axis X-X.

In the embodiment of fig. 8 between the winch 5 and the towing
15 point 2, especially the element 9, a guide 34 is provided, for guiding the cable further towards the winch 5. In this embodiment the guide 34 comprises at least two wheels or rolls 35 between which the cable 4 is guided towards the winch 5. The guide 34 provides for guiding to better allow the cable 4 to be wound onto or from the winch 5, in an ordinary way, which means the cable
20 being wound spiralling onto and/or from the winch 5, and/or independent from the position of the towing point 2 and, especially, the element 9, relative to the winch 5.

In the embodiment of fig. 8 the cable is guided onto the element 9 by the guide 13 pivotable around the axis Y-Y. The guide apparatus 13 can be
25 provided with rolls 36 rotating freely around axis extending perpendicular to each other and/or the axis X-X and/or the longitudinal direction of the cable 4 at the apparatus 13. Thus the position of the cable relative to the element 9 is properly aligned.

The present disclosure can allow for 3 degrees of freedom in a towing
30 cable connection 6 namely two preferably perpendicular pivots around second

axis X-X and first axis Y-Y or first axis Y-Y and axis Z-Z, enabling a truly azimuthal towing point 2 apparatus design. A third degree of freedom is obtained by rendering and/or recovering towing cable 4 by towing winch 5. Jointly said three degrees of freedom span an effective 3D vector space with
5 regards to a towing cable connection 6. More specifically the three degrees of freedom can enable tugboat 1 to establish a towing cable connection 6 anywhere within a semi-spherical space as far as not obstructed by tugboat's 1 superstructure. The application of rotating element 9 further enables a friction free application of said azimuthal towing point. The towing point apparatus
10 can be a truly azimuthal friction free towing point design.

The present disclosure can achieve constant pulling force 7 in the towing cable connection 6 with minimal or nil friction between the towing point 2 and towing cable 4. More specifically said friction is minimized in case tug boat 1 moves relative to vessel V. Even more specifically said movements
15 particularly occur during adverse operating conditions including but not limited to heavy seas. The present disclosure thus can allow a tug boat 1 to operate in a greater many working conditions or sea states and in the greatest conceivable directions.

In fig. 8a in top view three positions of the towing point 2 are shown.
20 In the mid position the towing point 2 is in the mid sectional plane P, wherein the cable 4 extends straight from the winch 5 through the unit 34 and the cylinder 31 onto the wheel 9 and then over the boarding of the tug boat, still in the plane P. The axis Y - Y thereby extends substantially parallel to the deck 37 and perpendicular to plane P. The arm 10 is in an upright position. In this
25 position the cable 4 can passed the wheel extend in any position within the plane P, as long as it is not interfering with the superstructure of the tug boat 1, for example substantially horizontally or at an angle upward towards a vessel V (not shown).

At the top in fig. 8a a towing point position is shown in which the
30 unit 11 is moved to an end of the track 12, wherein the cable 4 extends over a

side of the tug boat 1. In this position the arm 10 has been pivoted around the axis X - X, due to rotation of the cylinder 31 within the bracket 32, whereas the bracket 32 has been rotated around the axis A - A relative to the unit 11, such that the cable 4 can again extend straight from the unit 34 through the
5 cylinder 31 onto the surface 30 of the wheel 9 and then through the apparatus 13 towards a vessel V (not shown in fig. 8). As can be seen in this position the axis Y - Y extends at an angle relative to the deck 37 such that the wheel 9 almost lies parallel to the deck 37. Obviously the cable can be pulled either in forward or backward direction F_s , F_r from this position without necessarily
10 changing the position of the wheel 9 and without adding any friction. When the cable is brought in the direction F_r to an extend further than when it extends straight from unit 34 through the cylinder 31 and over the wheel 9 through the apparatus 13, the apparatus 13 will pull the towing point 2 towards the mid position as discussed here above and/or reposition the angular
15 position of the wheel 9.

In fig. 8a at the lower side the towing point 2 is shown at the opposite end of the track 12, in which the cable 4 extends at an angle other than 90 degrees relative to the plane P and at an angle to the deck 37, i.e. not horizontally. In this position the axis Y - Y and therewith the position of the
20 wheel has been amended in order to keep the axis Y - Y perpendicular to a plane mainly defined by the cable on opposite sides of the wheel 9. Thus the cable 4 is led properly over the surface 30 of the wheel 9 substantially friction free.

In fig. 8b different positions of the apparatus 13 are shown, with the
25 arm 10 and thus the wheel 9 in a possible position. As can be seen the apparatus 13 can move along the periphery of the wheel 9. Should the cable 4 physically engage the apparatus 13, it will apply a force on the apparatus, leading to a reposition of the apparatus 13 relative to the wheel 9 and/or of a repositioning of the wheel 9 relative to the deck 37, which can be obtained by a
30 repositioning of the unit 11 relative to the track 12 and/or a repositioning of

the arm 10 relative to the bracket 32 and/or of a repositioning of the bracket 32 relative to the deck 37. Thus a proper alignment can always be ensured, preferably with minimal friction. The arm 10 can be balanced by a counter weight, positioned for example at a side of the axis X-X opposite the wheel 9.

5 The present invention is by no means limited to the embodiments shown and discussed thereof by way of example. Many variations thereof are possible within the scope of the present disclosure. For example the movement of a towing point along a track 12 on a tugboat can be initiated and/or supported by a power operated movement system such as a motor, which could
10 for example directly engage the track or could engage the unit 11 by a cable, belt or similar indirect drive mechanism. The track can lie in one flat plane or can be bent in multiple directions, for example following a curved deck 37. In embodiments the unit 11 can be in a fixed position. In embodiments there can be more than one towing point 2 provided on a tug boat, for example in
15 proximity of the bow and stern of the tug boat. A tug boat of the present disclosure can be provided with traditional propulsion units such as one or more propellers or jets, and is preferably provided with a series of azimuthal propulsion units such as but not limited to a rotor tug or docking unit as discussed before.

Claims

1. A tug boat (1) having at least one towing winch (5) and a movable towing point (2) apparatus, wherein said towing point (2) apparatus can guide a towing cable (4) from a towing winch (5) to a vessel (V) to be assisted, comprising a rotating element (9) that at least partly guides the towing cable
5 (4) such that the pulling force (7) on said cable (4) is transmitted to the tug boat (1) at least partly through said rotating element (9) when in use, said rotating element pivoting freely around a first axis (Y-Y) and said first axis (Y-Y) fixed to an arm (10) which in turn can pivot about a second axis (X-X), said second axis (X-X) being spaced apart from said first axis (Y-Y) and the second
10 and first axis (X-X and Y-Y) being non-parallel.
2. A tug boat (1) of claim 1, wherein the second axis (X-X) is fixed to a movable member (11), wherein said member (11) can move along a curve (12) in a plane preferably substantially parallel to a deck of the tug boat (1).
3. A tug boat (1) of claim 1, wherein the second axis (X-X) is fixed to a
15 movable member (11), wherein the member (11) can move along a substantial straight line in a plane preferably substantially parallel to a deck of the tug boat (1).
4. A tug boat (1) of claim 1, wherein the second axis (X-X) is fixed to a movable member (11), wherein said movable member (11) can move partly
20 along a straight line and partly along an curve in a plane preferably substantially parallel to a deck of the tug boat (1).
5. A tug boat (1) of claim 1, 2, 3, or 4 wherein a guiding apparatus (13) is provided, guiding the towing cable (4) onto rotating element (9), wherein said guiding apparatus (13) is preferably attached to an arm (14) pivoting
25 freely about first axis (Y-Y), preferably parallel to and more preferably coinciding with first axis (Y-Y).

6. A tug boat (1) of claim 5 wherein said guiding apparatus (13) can comprise four or more rotating elements.
7. A tug boat (1) of claim 5 wherein said guiding apparatus (13) can comprise a towing eyelet, fairlead, chock or similar device.
- 5 8. A tug boat (1) of anyone of claim 1 to 7 with a balancing system for at least the arm, preferably comprising a counter weight attached to arm (10) juxtaposed to rotating element (9) with respect to the pivot axis.
9. A tug boat (1) of anyone claim 1 to 8 with an additional rotating element attached to arm (10) between towing cable (4) and second axis (X-X)
- 10 with said rotating element pivoting freely along an axis substantially parallel to first axis (Y-Y).
10. A tugboat (1) of anyone claim 1 to 9 wherein said rotating element (9) can pivot freely around a further axis (A-A), which further axis can preferably extend:
 - 15 - substantially parallel to the arm (10);
 - substantially parallel to a line crossing both second axis (X-X) and first axis (Y-Y); and/or
 - crossing the first axis (Y-Y) substantially perpendicularly when the arm is in a substantially upright mid position.
- 20 11. A tugboat (1) according to claim 10 with an additional guiding apparatus (16) between rotating element (9) and towing winch (5) that can also freely pivot around an axis substantially parallel to or coinciding with first axis (Y-Y).
12. A tugboat according to anyone claim 1 to 11, wherein the winch is a
- 25 render and recovery winch.
13. A movable towing point apparatus for use in a tugboat according to anyone claims 1 to 11, said movable towing point apparatus comprising a rotating element (9) that at least partly guides the towing cable (4) such that the pulling force (7) on said cable (4) is transmitted to the tug boat (1) at least
- 30 partly through said rotating element (9) when in use.

14. Method for assisting a vessel (V) by a tug boat (1) by connecting a towing cable (4) between a winch (5) on the tug boat (1) and the vessel (V), wherein on the tugboat (1) the towing cable (4) is guided by a movable towing

point (2) apparatus, such that the position of the towing point (2) apparatus is adjusted relative to the tugboat (1) depending on the position of the vessel (V) relative to the tug boat (1), wherein the towing cable (4) is guided by and/or over the towing point (2) apparatus substantially friction free.

15. Method for assisting a vessel (V) with a tug boat (1), by connecting a towing cable (4) between a winch (5) on the tug boat (1) and the vessel (V), wherein on the tugboat (1) the towing cable (4) is guided by a movable towing point (2), and wherein the position of the towing point (2) is adjusted relative to the tugboat (1) depending on the position of the vessel (V) relative to the tug boat (1), wherein the towing cable (4) is guided over a rotating element (9) such as a roll or wheel of the towing point (2) or forming the towing point (2), which rotating element is rotated on an axis which is moved relative the tug boat.