

IMPROVED HULL OF A TUGBOAT AND TUGBOAT COMPRISING SAID IMPROVED HULL

5 The present invention relates to an improved hull of a tugboat intended to tow and manoeuvre vessels or like, as well as to assist vessels in danger due to damages or accidents.

 More specifically, the invention relates to the structure of the hull of a tugboat configured in such a way as to allow the tugboat itself to have a greater power, both towing and pushing, which can be applied to the
10 vessel to be towed/assisted, as well as greater maneuverability, compared to the tugboats of known type,

 In general, a tugboat is a boat that operates in water spaces, harbors, bays, navigable channels, lakes and rivers, the purpose of which is to transfer mechanical energy from itself to the vessel to be
15 towed/assisted, through its engine and its propulsors.

 If it is provided with machinery and structure which are appropriate in shape, size, type and materials, a tugboat can also navigate in open sea, without geographical limits of navigation and regardless of sea conditions.

 Currently, there are several known tugboats for towing vessels.

20 A first tugboat of known type is described in the patent U.S. 3,750,607.

 Said tugboat includes a shallow hull, symmetrical both transversely and longitudinally, which has a flat bottom and vertical sides joined to said bottom part by a double chine underbody, portions at the bow and stern
25 symmetrically inclined upward from said flat bottom, and a generally rectangular profile, when viewed in plan, with flat straight ends and flat straight sides joined by rounded edges.

 Furthermore, said tugboat comprises omnidirectional thruster means which are supported by inclined portions of said hull and extend below the
30 level of said bottom part and the protection means (keels or skeg) which are supported by and below said hull and extend below said thruster means, and are centered with respect to the center line of the bow and the stern of said hull.

However, said known tugboat has some disadvantages.

5 A first disadvantage is that said tugboat has a underbody (i.e. the part of the hull which is intended to be submerged) which is flat and has a low draft, so as to allow a flow of water to be moved undisturbed by the propellers of propulsors, which underbody must meet the following two requirements.

10 The first requirement of said tugboat is related to the depth of the hull which must be lower compared to the length of the tugboat, generally of 1.8 m, and propulsors which protrude entirely from said flat under body for other 3m.

With particular reference to the first requirement, the underbody of said tugboat is a flat keel, so as to allow a flow of water is moved undisturbed by the propellers.

15 In other words, the tugboat described in the patent U.S. 3,750,607 is a vessel intended for the assistance of vessels or like in protected waters, without being able to the offshore navigation, which tugboat is characterized by a hull which has a high width, a flat bottom, wherein a lower part of the hull is intended to be immersed in shallow water, and is provided with azimuth propulsors arranged along the longitudinal axis.

20 A second disadvantage, related to the fact of having a underbody being flat and with a low draft, is given by the fact that said tugboat does not offer the required resistance to side dragging, when it is engaged in towing operations or escort.

25 Again a disadvantage of the tugboat is that propulsors are exposed to the risk of being damaged or destroyed in the case where the tugboat touches the sea bottom, as the keels, being mere semistructural appendages, would not resist to the impact with the sea bottom itself.

30 A further disadvantage of this tugboat is given by the difficulty for the same to transfer power to the vessel to be towed/pushed when it is alongside to it. In such a situation, the tugboat has its longitudinal axis parallel to that of the vessel to be pushed/towed and, in the case it uses all the nominal power of the engines, having no support in the submerged part, but only at the level of the rubber fender placed on the shear strake,

has difficulties for pushing this vessel, because the force applied by the propulsors on the point of exertion risks to overturn the tugboat, creating a high overturning moment. By way of an example, it should be considered that the thrust exerted by a tugboat of 60 tons bollard pull on a fixed exertion point, if laterally applied while the tugboat accompanies the vessel during the maneuvering, would cause a overturning moment at least equal to the result of the multiplication of 60 tons by 3.5 meters (distance between the propellers center and the exertion point), which is unacceptable for such a tugboat.

10 A second tugboat of known type is described in patent U.S. 5,694,877.

However, also such a tugboat has the same disadvantages mentioned above for previous tugboat.

A further disadvantage of the tugboat described in said patent US 5,694,877 is the fact that, due to the arrangement of the propulsors, the commands given by an operator to the tugboat are not intuitive and therefore the operator must take into account the offset position of the propulsors to achieve the desired advancing component (with reference to the course of the tugboat) or the desired towing component on the tow cable or the desired pushing component.

20 Again a disadvantage of said tugboat is given by the fact that, in order to increase stability, inherently deficient in hull having a flat bottom, the ratio between the width and length of the tugboat was increased so that this ratio is even greater than 70%. If on the one hand, this increases the stability of the tugboat, on the other hand it complicates his maneuverability in small water spaces and makes difficult the navigation in open sea, due to the excessive width and low depth of the submerged underbody.

25 A vessel of known type is described in patent application WO 2011/139154.

Such a vessel comprises a hull on the bottom of which two lateral keels are fixed, as well as first thruster means and second thruster means. Particularly, said keels serve as support elements for the vessel in a dry

dock.

However, this vessel has the disadvantage that the water flow generated by the first (second) thruster means interferes with said keels, reducing the power generated by the second (first) thruster means. In particular, the water flow is first obstructed by the keels and, despite a quantity of water of said water flow is dispersed into the surrounding environment as a result of the impact with the keels themselves, the greater water quantity of said water flow reaches said second (first) thruster means, interfering with said thruster means.

Embodiments of the present invention seek to overcome said disadvantages by providing an improved hull of a tugboat for towing/assisting a vessel, configured in such a way that, when a water flow is generated by first (second) thruster means of the hull, this water flow is channeled within the keel of the hull in such a way that the greater quantity of water of said water flow may be dispersed into the surrounding environment, below the keels, and only a minimal amount of water of said water flow may reach second (first) thruster means. In this way, it may be avoided that the thruster means towards which the water flow is directed (i.e. underflow thruster means) lose power. Consequently the efficiency of said thruster means may be improved.

Embodiments of the invention also seek to provide an improved hull configured in such a way to allow each component of the hull to participate in the overall structural strength of the hull itself.

Embodiments of the invention further seek to provide an improved hull configured in such a way as to allow the tugboat to have a higher directional stability, to oppose side dragging during the towing of a vessel or an escort service of a vessel, have a greater maneuverability, independently of the dimensions of the water spaces, making it suitable for navigation both in open sea and in protected waters.

Embodiments of the invention also seek to provide an improved hull of a tugboat configured in such a way as to allow the tugboat to transfer to said vessel a greater power, both towing and pushing.

Embodiments of the invention also seek to provide a tugboat comprising

said hull.

5 In the following it will be indicated with water plane the surface of separation between the submersed part of the hull or underbody and the emerged part of the hull which defines the level of the fluid on which the vessel floats, with base line the parallel to the water plane which passes through the keel point, wherein the keel point is the intersection between the profile of the hull within the outer surface (shell plating) of the the hull itself and the perpendicular to the hull, with water lines the lines between the hull and the planes parallel to the water plane, and with main section 10 the section which encloses the largest submerged area.

There is disclosed a hull that has a monolithic structure, wherein the keels are integral with the hull itself and form a tunnel with a portion of the bottom of the hull, and wherein first thruster means and second thruster means, arranged respectively at bow and stern, are aligned along the 15 same axis.

According to a first aspect of the present invention, there is provided an improved tunnel-hull of a tugboat for towing/assisting a vessel, said tunnel-hull having a water plane, a base line, a main section,
5 as well as a longitudinal axis dividing said tunnel-hull in a first lateral part and a second lateral part, said tunnel-hull comprising a bottom, a bow, a stern, and further comprising: a underbody, said underbody comprising a first keel and a second keel, wherein said first keel is parallel to and faces said second keel, first thruster means and second thruster means, wherein
10 each keel is arranged on a respective side of said underbody, in a substantially central position, and is connected to said underbody respectively in correspondence of the bow and the stern of said tunnel-hull, said two keels extending in depth perpendicularly or in a substantially perpendicular manner so as to have a draft equal to or greater than that of
15 said first and second thruster means, and wherein said first thruster means and said second thruster means are positioned respectively at the bow and stern of the tunnel-hull, and are substantially aligned along said longitudinal axis of said tunnel-hull; and wherein said two keels are integral with said tunnel-hull and are configured in such a way that they
20 form a tunnel with at least a portion of said bottom of said tunnel-hull, and

wherein said tunnel-hull has a longitudinal section having a concave bow portion, a concave stern portion and a convex intermediate portion, positioned between said bow portion and said stern portion, and has a first concave bottom portion which extends from said first thruster means to
5 said main section, and a second concave bottom portion which extends from said second thruster means to said main section; said two concave bottom portions being substantially symmetrical with respect to said main section; each concave bottom portion comprising a respective first portion, externally to said tunnel, which extends from the respective thruster
10 means to the keels, and a second portion, internal to said tunnel, which extends from the keels to the main section, said first and second thruster means being arranged in said first portion, externally to said tunnel, of a respective concave bottom portion, so that, when a water flow is generated by said first thruster means or by said second thruster means,
15 said water flow is channeled within said tunnel, following a respective concave bottom portion, and only a minimal amount of water of said water flow reaches respectively said second thruster means or said first thruster means.

It is preferable that said two keels are in a position shifted toward the
20 bow of said hull.

According to embodiments of the invention, said first thruster means and said second thruster means can have a respective center and said first thruster means and said second thruster means are arranged so that
25 said base line of said hull passes from each center or above each center.

Advantageously, said hull can comprise a fin centrally arranged on the bottom of said hull, at the stern of the hull itself; wherein said fin is preferably integral with said hull.

Again according to embodiments of the invention, said hull can comprise a first pushing fender and a second pushing fender, each of
30 which is externally arranged to the hull, on a respective lateral part, so as to be below said water plane. Particularly, said pushing fenders are positioned on the hull so as to be in correspondence with said base line of said hull.

Furthermore, said hull can comprise a third pushing fender, arranged
35 externally to the hull so as to be above said water plane.

Particularly, said first thruster means and said second thruster means can respectively comprise at least one azimuth propulsor.

According to a second aspect of the present invention, there is provided tugboat for towing/assisting a vessel, wherein it comprises a tunnelhull according to the first aspect, and wherein said first thruster means are driven by a first engine, said first engine being positioned at the bow of said tunnel-hull and connected to said first thruster means by a first shaft, and wherein said second thruster means are driven by a second engine, said second engine being positioned at the stern of said tunnel-hull and connected to said second thruster means by a second shaft; said engines having a respective longitudinal axis and being arranged within the tunnel-hull, in a respective lateral part of it, in such a way that the longitudinal axis of each engine forms with the longitudinal axis of said tunnel-hull a respective angle.

It is preferable that the value of each angle is between 0° and 90° .

It is further preferable that said longitudinal axes of said motors are parallel and said angles are equal.

According to embodiments of the invention, said tugboat can comprise a winch arranged at the bow of said hull, in the proximity or in correspondence of said first thruster means, and/or a winch arranged at the stern of said hull, in proximity or in correspondence of said second thruster means. A respective tow cable can be wind/unwind on each winch in such a way that the force for towing/assisting said vessel, exerted by a winch at the bow or stern, is applied on a respective point of said bow or said stern.

In particular, said tugboat can comprise a central control bridge and at least one corresponding chock for each winch, in such a way that:

5 - said winch is arranged between said control bridge and said bow, and the corresponding chock is arranged between said winch and said bow; and/or

 - said winch is arranged between said control bridge and said stern, and the corresponding chock is arranged between said winch and said stern.

10 Again according to embodiments of the invention, said engines can be positioned externally to said control bridge, wherein said control bridge has preferably a substantially circular section.

 In a first embodiment, the tugboat can comprise an engine room, which comprises said two engines.

In a further embodiment, the tugboat can comprise two engine rooms, each of which is respectively arranged at bow and stern of said hull and comprises a respective engine.

Furthermore, said tugboat can comprise steering and controlling means for steering and controlling said first and second thruster means, said steering and controlling means being aligned along an axis which coincides with said longitudinal axis.

The present invention will be now described, for illustrative, but not limitative purposes, according to an embodiment, making particular reference to the enclosed drawings, wherein:

Figure 1 is a perspective view of the hull of a tugboat according to the present invention,

Figure 2A is a three dimensional view of the longitudinal section of the hull of Fig. 1, without a keel, thruster means and fenders;

Figure 2B is a side view of the hull of Fig. 1;

la figura 3 è una sezione dello scafo di fig. 1 che mostra i primi ed i secondi mezzi di spinta, nonché i rispettivi motori di detti mezzi di spinta, disposti all'interno dello scafo stesso, dove le chiglie sono state asportate;

Figure 3 is a section of the hull of Fig. 1 showing the first and second thruster means, as well as the respective engines of said thruster means, arranged inside the hull itself, wherein the keels have been cut away;

Figures 4A-4B are respectively a first view and a second top view of the hull of Fig. 1;

Figures 5A-5B are respectively a view of the rear and front of the hull of Fig. 1;

Figure 5C is a side view of the bow part of the hull of Fig. 1;

Figure 5D shows the water lines of the hull of Fig. 1 seen from the stern;

Figure 5E shows the water lines of the hull of Fig. 1 seen from the bow;

Figure 5F shows a comparison between the water lines of the hull of Fig. 1 seen from the bow and the water lines of the hull of Fig. 1 seen from the stern;

Figure 6 is a side view of a first embodiment of a tugboat for towing/assisting a vessel, which comprises the hull according to the invention;

Figure 7 is a rear view of the tugboat of fig. 6;

5 Figures 8A-8B schematically show the tugboat of fig. 6, while it respectively exerts the function of indirect and direct escorting of a vessel;

Figure 9 is a first top view of the tugboat of fig. 6 from which a portion has been cut away to show the control bridge of the tugboat itself;

10 Figure 10 is a second top view of the tugboat of fig. 6 from which a portion has been removed to show the engine room of the tugboat itself, below the control bridge;

Figure 11 is a top view of a second embodiment of the tugboat, from which a portion has been removed to show two engine rooms of the tugboat itself, below the control bridge.

15 With reference to Figures 1-5, a hull 1 for a tugboat R (shown in Figures 6 and 7) for towing a vessel is disclosed.

Said hull 1 comprises a hull (i.e. the part of the hull intended to be submerged) and two deep keels, a first keel 11 and a second keel 12, the latter facing said first keel, which have a first end on the underbody 2 and
20 a second free end, wherein said two keels extend from said underbody 2 downwards in perpendicular or substantially perpendicular manner (Figs. 1, 2 A, 2B). Said two keels 11, 12 are parallel and arranged at the sides of the hull 1, in a substantially central position, and are connected to said underbody 2 respectively in correspondence of the bow and the stern of
25 said hull 1. In particular, said keels 11, 12 are a single piece with the hull 1 and are configured in such a way as to form a tunnel 14 with at least a portion of the bottom 1A of said hull 1. In other words, the tunnel 14 is a downwardly open tunnel, wherein the keels 11, 12 are the side walls of said tunnel and said at least a portion of said bottom 1A of the hull 1 is the
30 upper part of said tunnel.

Therefore, the hull object of the invention is a monolithic hull. This allows each component of the hull to participate in the overall structural strength of the hull itself. In the case of the tugboat R provided with said

hull and capable of transferring a quantity of kinetic energy to a vessel, when the tugboat goes alongside to the vessel for pushing it, the impact areas of the hull absorb the shock and transmit to said vessel the thrust power in a homogeneous way. This amount of kinetic energy is high for both the speed of the tugboat, when the latter goes alongside to the vessel, and the mass of the tugboat concentrated in a reduced volume of the hull of the tugboat itself.

First thruster means 3 and second thruster means 4 are arranged on the hull 1, in correspondence respectively of the bow and stern. In particular, said first thruster means 3 and said second thruster means 4 are arranged on the hull 1 so as to be aligned along a longitudinal axis L (Fig. 4A).

According to a peculiar feature of the invention, the hull 1 has a first airfoil W1 which extends from the bow, and in particular by the first thrusters means 3, to the main section SM of the hull and a second airfoil W2 which extends from the stern, and in particular by the second thruster means 4, to the main section SM of the hull. Said two airfoils W1, W2 are substantially symmetrical with respect to the main section SM of the hull. In particular, the first airfoil W1 of the hull 1 comprises a first portion, external to the tunnel 14, which extends from the first thruster means 3 to the keels 11,12, and a second portion, internal to the tunnel 14, which extends from said keels to the main section SM of the hull. The second airfoil W1 of the hull 1 comprises a first portion, external to the tunnel 14, which extends from the second thruster means 4 to the keels 11,12, and a second portion, internal to the tunnel 14, which extends from said keels to the main section SM of the hull. Said first thrusters means 3 and said second thruster means 4 are arranged on a first portion, external to the tunnel 14, of a respective airfoil W1, W2.

In particular, the hull 1 has first cross sections S1, S2, S3,... Sn, each of which is disposed between said first thruster means 3 and said main section SM of the hull, and second cross-sections S1', S2', S3', ... Sn', each of which is disposed between said second thruster means 4 and said main section SM of the hull. Said first cross sections S1, S2, S3, ... Sn and

11

said second cross sections $S1'$, $S2'$, $S3'$,... S_n' increase progressively according to a respective airfoil $W1$, $W2$ (Fig. 2B, 3) in the direction that goes from the respective thruster means to the main section SM .

5 The general configuration of the hull, with particular reference to airfoils $W1$, $W2$ and the keels 11, 12, is designed to reduce the power losses of the thruster means arranged aligned along the same axis, i.e. the longitudinal axis L of the hull 1, thereby increasing the efficiency. In fact, each airfoil $W1$, $W2$ of the hull 1 together with the tunnel 14, formed by the keels 11, 12 being in one piece with the hull 1, allows to channel a
10 water flow generated by the first thruster means 3 or the second thruster means 4 inside the tunnel itself. Thanks to the tunnel 14 and each airfoil $W1$, $W2$ of the hull 1, the water flow first undergoes an acceleration, substantially up to the middle of said tunnel, i.e. in correspondence of the main section SM of the hull 1, and then, in proximity of the middle of said
15 tunnel, begins to decelerate because the bigger amount of water of said water flow tends to disperse into the surrounding environment, below the keels. Since the tunnel 14 is a downwardly open tunnel, the greater amount of water of the water flow has a component which is dispersed downwards, according an airfoil of the hull. In this way, only a minimal
20 amount of water of said water flow reaches respectively said second thruster means 4 or said first thruster means 3.

With such a configuration of the hull 1, the water flow generated by the first (second) thruster means increases its speed as said water flow is obliged to follow an airfoil and to be channeled in the tunnel, and reaches
25 its maximum speed substantially at the tunnel middle point, where the pressure of water is minimal (technical effect due to the known laws of fluid dynamics). The increase of speed of the water flow generates a thrust that, is higher than that generated from the hulls of known type with the same power. Once the water flow has passed the tunnel middle point, its
30 speed decreases as the greater quantity of water of said water flow tends to disperse into the surrounding environment, below the keels.

Figures 5D and 5E show the water lines of the hull seen from the bow and stern respectively. Figure 5F shows a comparison of the water

lines of the hull as seen from the bow (the right part of the figure) with the water lines of the hull seen from the stern (the left part of the figure).

Advantageously, the underbody 2 of the hull 1 participates and increases the thrust applied to the hull by thruster means aligned along the longitudinal axis of the hull, the efficiency of which is improved by virtue of the fact that a minimum amount of water flow generated by the first (second) thruster means reaches the second (first) thruster means, interfering with said second (first) thruster means.

Another advantage is given by the arrangement of the two keels 11, 12 which improves both the stability of the course of the tugboat and the resistance to side dragging of the tugboat itself, when said tugboat is engaged in an escorting/towing function.

In the example being described, each of said thruster means 3, 4 has a longitudinal axis D which is inclined with respect to the base line B in such a way as to form an angle θ , between 0° and 7° , between said longitudinal axis L and an axis E perpendicular to the base line B. Said first thruster means 3 and said second thruster means 4 comprises a respective azimuth propulsor 31, 41. A first azimuth propulsor 31 is provided at the bow of the hull 1 and a second azimuth propulsor 41 is provided at the stern of the hull itself. Each azimuth propulsor 31, 41 is driven by a respective engine 33, 44 (fig. 3).

Furthermore, said hull 1 comprises a fin 13 which is centrally disposed between said two keels 11, 12, at the stern of the hull 1. Such a fin 13 has multiple functions: to support the rear of the tugboat when the latter is in the dry dock, to stabilize the dynamic behavior of the hull during the navigation, to slow down at least partially the speed of the water flow generated by the first (second) thruster means and directed towards the second (first) thruster means so as to increase the efficiency of said second (first) thruster means. Said fin 13 is preferably one piece with the hull 1 so that the entire structure of the hull is monolithic.

According to another peculiar feature of the invention, the configuration of the hull is configured in such a way that the draft of said keels 11, 12 is greater than that of said thruster means 3, 4. In other

words, the free end of said keels 11, 12 has a depth greater than that of the azimuth propulsors 31, 41. Although in the example being described said keels have a depth greater than the azimuth propulsors, said keels may have a depth equal to or substantially equal than that of the azimuth propulsors, without departing from the scope of the invention. This means that the azimuth propulsors 31, 41 never cross a horizontal plane O tangent to the free ends of the keels. Therefore, the configuration of the hull 2 allows to said azimuth propulsors 31, 41 to be incorporated in the hull 1, in a respective first portion of each airfoil W1, W2, external to the tunnel 14. Compared to the hulls of known type, wherein the submerged part is constituted in greater measure by the azimuth propulsors (about 3 meters), in particular by the propellers, and to a lesser extent by the part of the hull below the water plane (about 1.5 meters), in the hull 1 of the invention, the submerged part is formed directly from the part of the hull below the water plane G, as the azimuth propulsors 31, 41 does not increase the depth of the submerged part of the hull 1, being incorporated in the hull itself. Moreover, advantageously, in the case where the tugboat R both in dry dock for repair or maintenance, said azimuth propulsors 31, 41 do not touch the support plane. Similarly, in the case where the tugboat R is accidentally aground, said azimuth propulsors 31, 41 do not touch the the sea bottom.

With particular reference to Figures 4A, 4B, the hull 1 has a longitudinal axis L which divides it into a first lateral part L1 and a second lateral part L2 and a transverse axis T that divides it into a first front part A1 and a second rear part A2, including respectively the bow and the stern of said hull 1. In particular, the hull 1 has a structure configured in a such way that the front part A1 is different from the rear part A2, and more particularly that the front part A1 is asymmetrical with respect to the rear part A2.

As previously said, said thruster means 3, 4 are aligned along the longitudinal axis L of the hull 1. This allows the tugboat R to ensure the thrust directly at the ends of its longitudinal axis and control the power transferred to the vessel to be towed/assisted, guaranting maximum

maneuverability and maximum control of said vessel.

In the embodiment being described, said thruster means 3, 4 are arranged in such a way that the base line B of the hull 1 passesthrough the center of said thruster means 3, 4, i.e. the center of the propellers of the azimuth propulsors 31, 41. In other words, the propellers of the azimuth propulsors 31, 41 rotate around a rotation axis and the base line B coincides with said rotation axis.

Although not shown in the figures, the base line B of the hull 1 can pass above the center of said thruster means, in such a way that the greater part of the water flow generated by the thruster means is not obstructed by the underbody.

According to the invention, the hull 1 is configured in such a way that it has a ratio between its width and its length of not more than 1:2, and the underbody 2 of the hull 1 is configured in such a way that the ratio between the depth of said underbody and the width of the hull is not more than 1:3. In particular, the underbody is configured in such a way as to have a high displacement so that the tugboat R has a greater stability with respect to a tugboat of known type with the same barycenter.

The particular configuration of the hull 1, and therefore of the underbody 2 being part of said hull, allows the tugboat R to have a barycenter in a lower position than that of the known tugboats, generally flat, so that said tugboat R has a greater stability and a good sea-keeping behaviour during navigation compared to the known tugboats. Indeed, the fact that during navigation, the volume submerged in water comprising the hull object of the invention is greater than that of the known tugboats, makes it more stable.

According to the invention, the hull 1 comprises a first pushing fender 10A and a second pushing fender 10B, each of which is arranged externally to the hull itself, on a respective lateral part L1, L2 so as to be always below the water plane G, during the navigation of the tugboat R. In particular, each pushing fender 10A, 10B is disposed on a respective lateral part L1, L2 of the hull 1 in such a way as to be on the base line B of the hull itself. Hence, said pushing fenders 10A, 10B are positioned on the

hull 1 at the same height of the center of the propellers of the azimuth propulsors 31, 41 (Figs. 5A, 5B, 5C).

In the case of lateral thrust of a vessel by the tugboat R, the mechanical energy is transmitted to the underbody of the vessel, through both the hull of the tugboat and that of the vessel, and said pushing fenders 10A, 10B allow a homogeneous lateral thrust so as to oppose the overturning moment, since the hull has a monolithic structure.

Furthermore, the keels 11, 12 of the hull always participate to the displacement of the vessel and their contribution is not variable in function of the angle of inclination of the tugboat.

It is preferable that each pushing fender 10A, 10B is made of rubber and has a cylindrical shape.

Advantageously, due to the configuration of the hull 1 and to said pushing fenders 10A, 10B, the tugboat R can push a vessel to be towed/assisted with all the thrusting force of its propulsors, keeping its longitudinal axis parallel to that of said vessel, in such a way as to accompany the vessel in advancing and, at the same time, apply a thrust on it. Indeed, the fact that the pushing fenders 10A, 10B are positioned on the same axis that passes through the center of the propulsors, allows to oppose to the overturning moment, caused by the same propellers, when the tugboat R pushes at full power the vessel to be towed/assisted, with its longitudinal axis parallel to the longitudinal axis of said vessel. Consequently, such a vessel can be pushed safely and accompanied by the tugboat in its advancing.

It is also preferable that said tugboat R comprises a third pushing fender 11 which is arranged externally to the hull 1 so as to be above the water plane G.

In light of the foregoing, the hull 1 object of the invention is characterized by a no flat under body, which has a stern part different from the bow part and two azimuth propulsors respectively positioned at the bow end and the stern end, and it is deeper with respect to that of the known hulls, wherein the water lines are designed to allow minimal interference of the water flow with the propellers of the azimuth propulsors.

As already said, the airfoils W1, W2 of the hull 1 and the tunnel 14 allow to channel the water flow inside the tunnel 14 itself and give a directional stability to the tugboat during navigation, and also to oppose to side dragging, during the towing of a vessel or an escort service of a vessel.

5 Therefore, when a tugboat comprising said hull is in the water, in order to move said tugboat in a first direction, said first thruster means 3 take water from the surrounding environment and generate a water flow in a second direction, opposite to said first direction. As previously said, due to the configuration of the hull, the speed of said water flow increases up
10 to middle point of the tunnel 14 (i.e. in correspondence of the main section SM of the hull), where it reaches the maximum speed, and where the pressure of water is minimal. Then the speed begins to decrease as the greater amount of water of said water flow tends to disperse into the surrounding environment, below the keels, and a minimum quantity of
15 water of said flow of water reaches the second thruster means 4. Consequently, the power loss of the thruster means is reduced, due to the fact that thruster means are arranged aligned along the same axis, and the efficiency of the second thruster means 4 increases. The underbody 2 of the hull 1 participate and increases the thrust applied to the hull by
20 thruster means. In fact, the underbody 2 amplifies the thrust power at low speeds, typical of a tugboat, whose maximum towing/pushing force exerted on a vessel occurs at a speed close to zero velocity.

 If a water flow is generated by said second thruster means 4, only a minimal amount of water of said water flow reaches said first thruster
25 means 3.

 With reference to Figures 6 and 7 is shown a tugboat R which comprises the hull 1 object of the invention.

 Said tugboat is provided with two winches V (towing winches), on each of which a tow cable C is wind/unwind. A first winch V is positioned
30 at the bow of the hull and a second winch V is positioned at the stern of the hull.

 With particular reference to the box of Figure 6, the detail of the first winch V positioned at the bow of the hull is shown.

Although not shown in the figures, the tugboat R can be provided with only one winch V, positioned at the bow or stern of the hull 1, or any number of winches.

5 The configuration of the underbody 2 provided with two keels 11, 12 being parallel and facing each other, allows to offer a high transverse resistance when the tugboat R exerts the function of indirect escorting in turning a vessel N which proceeds in the same direction of advancing of said tugboat, when it is necessary that the tugboat R exerts a strong force on the tow cable C using its engines at full speed ahead (Fig. 8A).

10 As can be seen from Figure 8A, the tugboat R exerts its towing force on the vessel V through the first winch V at the bow of the hull. Said winch V is positioned in the vicinity of the first thruster means 3, and preferably in correspondence of said thruster means 3, in such a way that the point of exertion of said towing force coincides with said first thruster means 3. In particular, said first winch V is positioned between the control bridge P of the tugboat R, centrally placed, and the bow of the tugboat itself, and the tow cable C exit a chok F positioned between said first winch V and said bow.

20 In the case of indirect escorting, the tugboat R goes full steam ahead.

25 The high displacement of the tugboat, the mass of the tugboat, the high ability to oppose to side dragging of the tugboat R, due to the configuration of the hull having a deep underbody and two keels parallel and facing each other, as well as due to the azimuth propulsors arranged at the ends of the longitudinal axis of the hull, the possibility of applying a towing power in a controlled manner along the longitudinal axis of the tugboat, the latter coinciding with that of the hull, amplify the operating capacity of the tugboat, and improve the safety of the towing operations in the indirect escorting function, avoiding that the tugboat R positions itself transversally to the direction of the tow cable (so-called girting phenomenon), loses the control and is therefore overturned.

30 Similarly, even when the tugboat R exerts a direct escorting function, the point of exertion of the towing force coincides with the first thruster

means 3 at the bow of the hull (Fig. 8B). In direct escorting function, the tugboat R reverses its motion, and its propulsion force is of opposite sign to that of a vessel N.

5 In both situations above described, in case of damage to its machines, the tugboat R aligns to the vessels N to be towed and the tension on the tow cable C tends to zero.

10 With reference to Figures 8A and 8B, the large arrow indicates the direction of advancing of the tugboat R, while the small arrows in the proximity of the azimuth propulsors 31, 41 of the tugboat R indicate the direction of the thrust.

Although not shown in Figures 8A, 8B, the tugboat R may exert its towing force to the vessel V through the winch V positioned at the stern of the hull.

15 Said second winch is positioned in the proximity of said second thruster means 4, and preferably in correspondence of said second thruster means, in such a way that the point of exertion of a towing force coincides with said second thruster means 4. In particular, the second winch V is positioned between the control bridge P and the stern of the tugboat R, and the tow cable C exits a chok F positioned between said
20 second winch and said stern.

25 With particular reference to Figure 9, the control bridge P of said tugboat R is schematically shown. Said control bridge P is positioned at the center of the tugboat R and is configured in such a way as to have a substantially circular shape, with the center corresponding to the point of intersection between the longitudinal axis L and the transverse axis T.

With reference to Figure 10, the engine room M of the tugboat R is schematically shown.

30 The engine room M is positioned below the control bridge P and comprises two engines, a first engine 33 positioned at the bow and connected to said first thruster means 3 by means of a first shaft 3A, and a second engine 44 positioned at the stern and connected to said second thruster means 4 by means of a second shaft 4B.

Said engines 33, 44 have a respective longitudinal axis A33, A44 and

are arranged on a respective lateral part L1, L2 of the hull 1 in such a way that their longitudinal axes are parallel and form a predetermined angle with respect to the longitudinal axis L of the hull, respectively an angle α and an angle β .

5 Although in the example being described the two longitudinal axes A33 and A44 of the engines 33, 44 are parallel, and therefore the angle α is equal to the angle β , it is possible to provide that said longitudinal axes are inclined with respect to the longitudinal axis L, without necessarily being parallel.

10 This solution allows to reduce the overall dimensions and extract one of said two engines or both engines directly from the main deck, when necessary, for example, in case of maintenance, without the need of cutting a portion of the outer wall of the hull 1 to obtain an opening, as happens for the tugboats of known type. In order to allow the extraction of
15 the engines, an opening and a closing element, such as a plate to be fixed on said the main deck to close said opening, are provided on the the main deck. In particular, an empty space between each engine and said closing element is provided. In other words, there are no electrical means or mechanical means or further elements or parts that may interfere with the
20 extraction of each engine from the above.

 In particular, each angle α and β may have a value between 0° and 90° . In other words, the value of each of said angles can be equal to 0° or greater than 0° up to a value equal to 90° . In the specific case in which the
25 value of each of said angles is 0° , the engines 33, 44 are arranged along the same longitudinal axis which coincides with the longitudinal axis L of the hull.

 Furthermore, said tugboat R comprises steering and controlling means (not shown in the figures) for steering and controlling said thruster means 3, 4, positioned in the control bridge of the tugboat itself, which are
30 aligned along an axis which coincides with the longitudinal axis L of the thruster means themselves, allowing the pilot of said tugboat to have an intuitive control of the direction and the power, both towing and pushing, in the desired direction. Indeed, the thrust is applied on the poles of the axis

of symmetry which coincides with the longitudinal axis and thus causes intuitive reactions of the tugboat to the variation of the commands.

According to a second embodiment of the tugboat R shown in Figure 11, the tugboat R comprises two engine rooms M1 and M2, separate
5 between them, arranged respectively at the bow and stern of the hull 1. In particular, the tugboat R comprises a first engine room M1, arranged at the bow, which comprises said first engine 33, and a second engine room M2, arranged at the stern, which comprises said second engine 44. This allows to remove any separation element, such as a septum or a bulkhead
10 that separates the engines 33, 44 by the respective thruster means 3, 4 connected to said engines.

Advantageously, as already mentioned, the hull object of the invention, due to its configuration, i.e. a hull having a under body with a high draft and provided with thruster means included in the hull, allows a
15 tugboat for towing/assisting a vessel to have a greater stability, greater maneuverability and to apply a power, both towing and pushing, on the vessel to be towed/assisted, without significant differences in terms of efficiency in every direction. Furthermore, the configuration of the hull with a high draft makes the tugboat suitable for a navigation not only in
20 protected waters, but even in the open sea. As a result, the stability obtained by the configuration of the hull allows on one hand that the ratio between the width and length of the tugboat does not exceed 1:2 for hulls of about 30m in length, so that said tugboat can move in restricted spaces, such as ports and locks, and on the other hand that the relationship
25 between the submerged part of the hull and the width of the tugboat does not exceed 1:3.

A second advantage is that the azimuth propulsors are protected from accidental impacts both during navigation and when the tugboat is in dry dock for maintenance.

30 Another advantage is the fact that it is possible to store a high quantity of fuel in the internal volume of the underbody, due to the configuration of the under body itself, so that a sufficient provision can be guaranteed even for offshore navigation.

21

The present invention has been described for illustrative, but not limitative purposes with reference to a preferred embodiment, but it well evident that one skilled in the art can introduce modifications to the same without departing from the relevant scope as defined in the enclosed

5 claims.

CLAIMS

1. Improved tunnel-hull of a tugboat for towing/assisting a vessel, said tunnel-hull having a water plane, a base line, a main section, as well as a longitudinal axis dividing said tunnel-hull in a first lateral part and a second lateral part, said tunnel-hull comprising a bottom, a bow, a stern, and further comprising:
- a underbody, said underbody comprising a first keel and a second keel, wherein said first keel is parallel to and faces said second keel,
 - first thruster means and second thruster means,
- wherein each keel is arranged on a respective side of said underbody, in a substantially central position, and is connected to said underbody respectively in correspondence of the bow and the stern of said tunnel-hull, said two keels extending in depth perpendicularly or in a substantially perpendicular manner so as to have a draft equal to or greater than that of said first and second thruster means, and wherein said first thruster means and said second thruster means are positioned respectively at the bow and stern of the tunnel-hull, and are substantially aligned along said longitudinal axis of said tunnel-hull;
- and wherein said two keels are integral with said tunnel-hull and are configured in such a way that they form a tunnel with at least a portion of said bottom of said tunnel-hull,
- and wherein
- said tunnel-hull has a longitudinal section having a concave bow portion, a concave stern portion and a convex intermediate portion, positioned between said bow portion and said stern portion, and has a first concave bottom portion which extends from said first thruster means to said main section, and a second concave bottom portion which extends from said second thruster means to said main section; said two concave bottom portions being substantially symmetrical with respect to said main section; each concave bottom

portion comprising a respective first portion, externally to said tunnel, which extends from the respective thruster means to the keels, and a second portion, internal to said tunnel, which extends from the keels to the main section, said first and second thruster means being arranged in said first portion, externally to said tunnel, of a respective concave bottom portion, so that, when a water flow is generated by said first thruster means or by said second thruster means, said water flow is channeled within said tunnel, following a respective concave bottom portion, and only a minimal amount of water of said water flow reaches respectively said second thruster means or said first thruster means.

2. Improved tunnel-hull according to the previous claim, wherein said two keels are in a position shifted toward the bow of said tunnel-hull.

3. Improved tunnel-hull according to any one of the preceding claims, wherein said first thruster means and said second thruster means have a respective center and in that said first thruster means and said second thruster means are arranged such that said base line of said tunnel-hull passes from each center or above each center.

4. Improved tunnel-hull according to any one of the preceding claims, wherein said tunnel-hull comprises a fin centrally arranged on the bottom of said tunnel-hull, at the stern of the tunnel-hull itself; said fin being preferably integral with said tunnel-hull.

5. Improved tunnel-hull according to any one of the preceding claims, wherein it comprises a first pushing fender and a second pushing fender, each of which is externally arranged to the tunnel-hull, on a respective lateral part, so as to be below said water plane.

6. Improved tunnel-hull according to the preceding claim, wherein said pushing fenders are positioned on the tunnel-hull so as to be in correspondence with said base line of

said tunnel-hull.

7. Improved tunnel-hull according to any one of the preceding claims, wherein it comprises a third pushing fender, arranged externally to the tunnel-hull so as to be above said water plane.

5 8. Improved tunnel-hull according to any one of the preceding claims, wherein said first thruster means and said second thruster means comprise respectively at least one azimuth propulsor.

9. Tugboat for towing/assisting a vessel, wherein it comprises a tunnel-hull according to any one of the preceding claims, and wherein said
10 first thruster means are driven by a first engine, said first engine being positioned at the bow of said tunnel-hull and connected to said first thruster means by a first shaft, and wherein said second thruster means are driven by a second engine, said second engine being positioned at the stern of said tunnel-hull and connected to said second thruster means by a
15 second shaft; said engines having a respective longitudinal axis and being arranged within the tunnel-hull, in a respective lateral part of it, in such a way that the longitudinal axis of each engine forms with the longitudinal axis of said tunnel-hull a respective angle.

10. Tugboat according to the preceding claim, wherein the value
20 of each angle is between 0° and 90°.

11. Tugboat according to claim 9 or 10, wherein said longitudinal axes of said motors are parallel and said angles are equal.

12. Tugboat according to any of claims 9-11, wherein it comprises a winch arranged at the bow of said tunnel-hull, in the proximity
25 or in correspondence of said first thruster means, and/or a winch arranged at the stern of said tunnel-hull, in proximity or in correspondence of said second thruster means, a respective tow cable being wind/unwind on each winch in such a way that the force for

towing/assisting said vessel, exerted by a winch at the bow or stern, is applied on a respective point of said bow or said stern.

13. Tugboat according to the preceding claim, wherein it comprises a central control bridge and at least one corresponding chock
5 for each winch, in such a way that:

- said winch is arranged between said control bridge and said bow, and the corresponding chock is arranged between said winch and said bow; and/or

- said winch is arranged between said control bridge and said stern,
10 and the corresponding chock is arranged between said winch and said stern.

14. Tugboat according to the preceding claim, wherein said engines are positioned externally to said control bridge; said control bridge preferably having a substantially circular section.

15. 15. Tugboat according to any of claim 9-14, wherein it comprises an engine room; said engine room comprising said two engines.

16. Tugboat according to any of claim 9-14, wherein it comprises two engine rooms, each of which is respectively arranged at bow and stern of said tunnel-hull and comprises a respective engine.

20 17. Tugboat according to any of claim 9-16, wherein it comprises steering and controlling means for steering and controlling said first and second thruster means, said steering and controlling means being aligned along an axis which coincides with said longitudinal axis.