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(54) **MOVABLE BALLAST FOR SAILBOAT AND SHIP**

BEWEGBARER BALLAST FÜR EIN SEGELBOOT UND SCHIFF

BALLAST MOBILE POUR BATEAU À VOILE ET NAVIRE

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Description

Technical Field

[0001] This invention relates to sailboats and partially to motorboats. More specifically, this invention describes equipment intended to improve the performance of a sailboat by increasing the stability, or "stiffness", - the ability of the sailboat to resist the heeling force of the sails. The stiffness, as it will be called in the following, is afforded by the righting moment. Enhancing the stiffness brings significant extra power to the sails and, furthermore, increases the equilibrium and the safety of boats in general. Good stiffness enables a ship to have all sails set wind abeam, whilst maintaining the boat at angles of about a normal heeling (the first 30 degrees of heeling). The greater the stiffness (or righting ability) of the boat, the more powerful the sails can be and the faster the boat can be.

Background

[0002] Sailboats must have a system ensuring stability to counterbalance the sails' thrust. Conventionally, this problem is solved in various ways in sailboats: multihulls have several hulls, big centreboard boats have inside or outside ballasts, keelboats have an outside fixed ballast also called fin keel. Some race keelboats have one or two movable keels. In addition all these sailboats can have several inside ballast tanks.

[0003] Since antiquity, the stability of sailing ships has benefited from various improvements. It should be noted that Galleons had an inside ballast made of stones piled in the bilges. This rudimentary system caused many tragedies, with the ballast prone to suddenly move leeward if the ship was strongly heeled by the sea or the wind. With the advent of metal ships, ballasts were in cast iron bolted through the bilges, and later in lead on smaller boats. The design of ships propelled by sails changed little by little with the advent of the garboard curves. This form made it possible to descend the ballast within the hull and thus to lower the centre of gravity, thereby increasing the lever arm and consequently the righting moment. In the beginning of the 20^{th} century, the most beautiful ships of the William Fife era usually had some 5 metres' draft, which allowed a very significant stiffness as soon as the boat was heeled and especially allowed to set gigantic sails. With the boating democratization and the advent of polyester moulded boats, the garboard forms disappeared, making place for bolted fin keels, which are easier and cheaper to manufacture. Today, in order to improve the stiffness, high-performance boats are equipped with keels that are named dagger or sabre type, very lengthened. Fin keels and dagger or sabre keels are also making the anti-leeway plane of the boat which is necessary to sail from close hauled to broad reach tacks.

[0004] Contrary to popular belief, to heel for a sailboat is unnecessary for its good operation. Heeling brings only detrimental effects, in addition to notable discomfort. The thrust of the sails is situated at several meters above the sea level, and once the boat is heeling, the thrust force is displacing itself on a point overboard, turning itself into an oblique directed downwards in the three-dimensional space. Decomposing that force, it gives: the leeway-force vector, the propulsive vector and a loading vector acting principally on the fore of the boat which is prejudicial to its performances. Hence, the more the sails are tilted, the more the boat nose is pushed into the stem wave, with other consequences amongst which the growth of the stem wave and the braking provided by it. For this reason and others, like discomfort, the less the boat is allowed to heel when close hauled, the better its efficiency.

[0005] There are several disadvantages to having only one ballast positioned down the anti-leeway plane. It is, for example, necessary to have several degrees of heeling before the righting moment becomes significant.

[0006] The ballasted swinging keel brought a beginning of response to this problem, allowing to anticipate the heeling by pre inclining the keel which increases the stiffness. But the anti-leeway plane, once tilted, is transformed into a foil and develops a undesired lift effect.

[0007] The double ballasted swinging keel system allows to partially solve this problem by presetting the incidence angles. In this system, the hinge axes are rotated slightly one towards the other in order to cancel out the lift effect.

[0008] Anyway, fixed keels or swinging keels require thick profiles in order to support the mechanical forces caused by the ballasts load. Together with the bulb of the ballast itself, this gives rise to significant drag resistance caused only by these appendages. Furthermore, the junction of any ballasted keel with the hull remains a major concern because in the event of contact with an object, e.g. a container, a whale, or - indeed more frequently - with the sea bottom, this point instantaneously becomes an Achilles' heel. Apart from these dangers, deep keels require much water below the hull which seriously restricts use. Indeed, not all marinas do have enough depth, and the most beautiful moorages may often be out of reach. In addition, hauling out and running aground are made dangerous. Finally, fishing nets, ropes and plastics are daily traps for deep keels.

[0009] The more the boat is designed to go fast, the more it requires stiffness. Increasing the stiffness quickly and on request is the dream of any skipper who likes to make his boat run. Many racing sailboats use ballast tanks in addition to their ballasted keel. An elegant solution, in the form of water is abundant outside, and the corresponding solution which allow to correct heel and trim angles on request by counterbalancing on side or aft are known. However, water ballasts have imperfections: filling and draining problems due to factors like their position, clogging and ventilation of the strainers, inherent slowness of the system, overload when using, volumes occupied in the accommodations, etc.

[0010] Thus it emerges that a movable ballast system inside a hull using a dense material like lead could be an advantageous solution. WO 91/19641 and FR 2818236 relate to systems which are based on movable ballasts inside a hull. However, they offer several disadvantages. The solution proposed in FR 2818236 can hardly be applied on a cruising sailboat because it occupies the complete space on the boat's centre and thus bans all crew movement in the hull. Moreover the weight is positioned high in the hull and this is detrimental to righting the boat, once capsised.

[0011] For both solutions, the mast must swing athwart ship to actuate the ballast which weakens the whole system. Indirectly resulting therefrom, good watertightness is almost impossible, which is a big disadvantage. Tilting the mast and the sails intentionally to actuate the system is simply aberrant since it is deteriorating the above problem of the sails thrust force acting overboard which is generating the prejudicing loading vector on the fore part of the boat.

[0012] WO 01/47769 A discloses a movable ballast system for a ship, in which ballast spheres inside a conduit are put into motion through smaller spheres. The smaller spheres are put into motion using mechanical or electrical means. The disclosure does not foresee means to avoid oxidation of the mechanical or electrical means.

[0013] It is therefore an object of the present invention to obviate at least some of the above disadvantages and to provide an apparatus comprising an improved movable ballast.

Summary

[0014] Aspects of the invention are set out in the accompanying claims.

[0015] In one configuration the tunnel or conduit may comprise sidewalls provided with a set of rails or tracks for the movable ballast. The movable ballast may be provided as a train set.

[0016] In yet another configuration the operation of the movable ballast in the tunnel or conduit may be manual.

[0017] In a further configuration the operation of the movable ballast in the tunnel or conduit may be power-assisted.

[0018] In yet a further configuration a mechanical force may be applied to the movable ballast.

[0019] In a further configuration the hermetically sealed tunnel or conduit may comprise a neutral atmosphere, preferably nitrogen.

[0020] In another configuration the tunnel may be built like a cylinder and the ballast like a two-headed piston. The ballast may be actuated by pressurising a gas or a liquid on one of its faces and releasing the gas or the liquid on its other face.

[0021] In yet a further configuration the piston has an articulated body allowing it to bend between its two ends.

[0022] In one confirmation the position of the movable ballast in the tunnel or conduit system may be controlled by a computerized means equipped with I/O ports e.g. a PLC

[0023] The computerized means may use one or move of the information of the heeling measure, the wind direction or the rudder position to monitor the position of the movable ballast.

[0024] Embodiments of the present invention may allow to increase on request and quickly, the stiffness of sailboats. Moreover, the present invention may also allow to control the heeling in order to improve comfort.

Brief Description of the Drawings

[0025]

Fig. 1 shows a sailboat with a ballast of the type for use with an embodiment of the present invention in a first operational state.

Fig. 2 depicts a sailboat with a ballast in a second operational state i.e. wind abeam.

Fig. 3 is a chart showing the torque exerted by a movable ballast positioned 100% windward for various heeling angles.

Fig. 4 is a chart illustrating the dependence of the righting moment on the heeling angle of an experimental 65-foot round-bilge sailboat.

Detailed Description

[0026] The stiffness and comfort of a sailboat may be improved considerably by means of a movable ballast moving in a tunnel or conduit built inside and close to the hull. A set of rails or tracks may be fitted around the tunnel sides, which allows the ballast to move accurately when the boat is sailing in a rough sea. The ballast may be made of a high-density material, such as lead. This allows the tunnel to be compact and it may be located under the floor and in principle may be hidden by the accommodations. The stiffness may be increased by moving the ballast windward to balance a part of the heel. If so designed, the trim angle may also be corrected on the same principle. The operation may be performed manually or automatically by computerized means like a PLC. In some configurations this system may be adapted to meet explosion-proof specifications.

[0027] According to a configuration of the present invention shown in Fig. 1, a movable ballast arrangement for a vessel, such as a sailboat, motorboat or ship, is located in a tunnel or conduit provided inside and preferably close to the bottom hull of the vessel. The movable ballast 11a to 11e is located in a tunnel or a conduit 12. The tunnel or conduit 12 may advantageously be composed of straight and/or a curved sections. A preferred shape of the tunnel or conduit 12 is a horseshoe shape, with the tips preferably being turned backwards, as shown in Fig. 1. In an alternative configuration, not shown in the Figures, the tunnel or conduit 12 may be built in endless loop form.

[0028] The tunnel or conduit 12 is built inside and close to the hull 10 and thus is, in theory, under the floors and hidden by the accommodations. A set of rails or tracks may be fitted around the tunnel sides, enabling the ballast 11a to 11e to work reliably in all positions even in a harsh environment. A certain level of watertightness is required for the tunnel in order to prevent intrusion of and thus obstruction by any object.

[0029] The ballast 11a to 11e may be actuated by a mechanical force by means of e.g. a cable, a toothed belt or a chain set. The cable, toothed belt or chain set may be endless. The ballast 11a to 11c may advantageously be operated manually, or via a mechanical appliance. Electric or hydraulic motors may be used to apply mechanical force on the ballast I 1a to I 1e. In an other configuration, one or various on-board electric motors may be used, at that time the ballast 11a to 11e operating like a ballast train set. A train set may comprise one ballast element or a plurality of ballast elements coupled together.

[0030] The ballast system may be built in twin or even plural arrangement, i.e. two or more ballast train sets may be operated independently from one another in order to solve more complex balancing and/or trimming problems. Moreover, the system may also comprise two or more tunnels or conduits. One or more of the tunnels may be built in endless loop form.

[0031] Whenever specifications may require explosion-proof criteria, the tunnel or conduit 12 can be foreseen as a pneumatic or hydraulic cylinder, and the ballast 11a to 11e provided like a two-headed piston. Thus the ballast 11a to I le can be moved by a pressurized medium like a gas or a liquid acting on one of its faces and propel it to the desired position while releasing partially or totally the medium pressure on its other face. It is of advantage if the gaseous or liquid medium operates in a closed circuit. In order to enable operation in a curved tunnel 12, the pistons 11a to 11c of the ballast may preferably be articulated between their heads by one or several joints, with each section optionally having a set of seals. The system may be managed by a computerized means equipped with I/O ports.

[0032] In a currently preferred configuration a fixed conventional inside ballast comprising about 65% of the total weight of on-board ballasts is completed by a movable ballast having the remaining weight balance. The movable ballast is arranged inside a tunnel or conduit having a horseshoe shape built flush on the hull, with the tips turned backwards as shown in Fig. 1. A set of tracks is fitted to the tunnel sides, enabling the ballast to move in all positions in a harsh and rolling environment. The ballast weight elements are preferably made of lead and joined onto electrically driven bogies. The bogies are equipped with wheels on their faces. Each bogie is powered by a motor, which may advantageously be supplied by a set of three-phase current track. The necessary energy is preferably provided by a bank of batteries which supply the three-phase current track through an industrial frequency generator placed in a watertight housing. The tunnel is preferably under neutral atmosphere (nitrogen) in order to prevent a chemical oxidation of the mechanical and electrical components. Each motor is coupled to a mechanical worm gear whose high gear reduction prevents the reversibility of the movement by the movable ballast. Each reducer is geared by means of a pinion engaged on a toothed rack fixed lengthwise in the tunnel.

[0033] An industrial Programmable Logic Controller (PLC) placed in a watertight housing may receive data from sensors to monitor the exact position of the movable ballast. E.g. infra-red communication system may inform the PLC about the state of the motors and the reducers. Furthermore the PLC may permanently measure one or more of the heeling, the trimming angles, the wind direction and force, the rudder position, the speed of the boat. From these data the PLC determines the state of the sea, course and/or tack. The PLC may also monitor the state of each battery and start the generator unit when necessary.

[0034] The autonomy time of such a system is significant, since the movable ballast does not move incessantly. Boat movements caused by the sea may be detected and filtered out by the program such that the ballast position is changed practically only when tacking. In harbour, or when sailing with the engine, or with the wind aft, the position of the ballast naturally is on the centre. As shown in Fig. 2, when sailing from close hauled to broad reach tack, the ballast 11a to 11e will be moved to a position at the windward side at the exact position conditioned by the heeling and trimming levels. E.g. Fig. 2 shows the wind 21 on portside and the ballast 11a to 11e moved windward. The balancing of the sail's thrust and particularly the loading vector acting on the fore part of the boat is done simply by positioning the ballast more or less into the aft facing tips 22 of the horseshoe.

[0035] A touch-screen communicating with the PLC may show the system state and may allow the skipper to modify some settings, if he wishes, as e.g. to reduce rolling of the boat.

[0036] In other configurations, less sophisticated embodiments may be used, without necessarily reducing the effectiveness.

[0037] For the best sailing efficiency and the crew's comfort, as soon as the sails are filled by the wind, the movable ballast takes its calculated position to counterbalance the heeling. As shown in Fig. 3, and independent of hull shape, the movable ballast positioned 100% windward exerts its greatest force when the boat is in regular heeling angles, i.e. from 0° to about 30°. Beyond this position, the stiffness goes down to become almost nil when the boat is heeled over at 90°. When this point is reached, the righting moment is almost no longer affected by the position of the movable ballast.

[0038] Fig. 4 shows righting curves of an experimental round-bilge sailboat having a fin keel weighing 65% of the total weight of the solid on-board ballasts, completed by a movable ballast having the 35% remaining, ratio as defined in a preferred configuration for a 65' sailboat. In addition and in the purpose to establish an objective comparison, the boat is equipped with an extra tank ballast system having a volumetric capacity of 300% of the volume of the full movable ballast tunnel, volume corresponding as made on race sailboats. Curve 41 shows the righting moment RM with the movable ballast inactive, i.e. positioned on the boat centre, or as if the boat was not equipped with it. Curve 42 shows the righting moment RM with the movable ballast active, the ballast beginning to move windward as early as 3° of heel, and moving on the other side once the boat is capsized over 90 degrees. Curve 43 shows the righting moment RM with the ballast tunnel inactive and the extra tank ballast system fully active, i.e. being refilled at 100% windward or yet 37% of its total volumetric capacity, the remaining percentage being positioned on the other side and aft. What stands out from these curves, and regarding the stiffness, is that the movable ballast system is boosting up to 325% the original righting moment from as early 3° of heeling and boost yet up to 22% at 40° of heeling, i.e. it is changing radically the efficiency of the boat which gains the same proportion of sails power without having to overload, when the tank ballast system with race characteristics brought only 96% at 3° and 9% at 40°, having to load an extra mass.

[0039] This movable ballast system according to the present invention may have one or more of the following advantages:

The movable ballast according to the present invention may improve efficiency, the system allows to enhance stiffness, thus providing a sail's power booster. By using a PLC, the operation of the system may be simplified since the PLC is managing in real time the full operation, liberating the skipper and the crew. The system may be implemented in the absence of (loaded) extra mass. Absence of added drag resistance, compared to the double ballasted swinging keel systems, since there are no supplementary outside components in the seawater. No draught augmentation is required to gain the stiffness. The system may be implemented in compact form and may provide improved watertightness. The integration of various data collected by the PLC may allow swiftness as the reaction is immediate when tacking. The watertight aspect of the tunnel and the inside components installed under an inert atmosphere allow to enhance reliability and durability. The full system may easily be fitted in the accommodations. The balancing of the sails thrust on the fore part of the boat may be automatically integrated. The movable ballast may be used to reduce the roll tendency when sailing wind aft or when mooring, It may be facilitated to over-heel or counter-heel the boat in order to decrease the hull's wet area when sailing by light wind, If it should ever happen, the movable ballast may help to overcome the Angle of Vanishing Stability (AVS) once the boat has capsized, The same batteries bank may be used to supply winches and windlasses too, The system may equip all types of sailboats, from ballasted keelboats to all types of centreboard boats or even multihulls. Motor yachts, workboats and trawlers may also gain enhanced stability, safety and improved comfort.

[0040] No doubt many other effective alternatives will occur to the skilled person. It will be understood that the invention is not limited to the described embodiments and encompasses modifications apparent to those skilled in the art lying within the spirit and scope of the claims appended hereto.

Claims

1. A sailboat comprising a movable ballast arrangement , wherein the movable ballast arrangement (11) is located in a tunnel or conduit (12) which is provided inside and preferably close to the bottom hull of said sailboat, and further comprises ballast weight elements that are made of lead, **characterised in that** said tunnel or conduit (12) is hermetically sealed, **in that** the tunnel or conduit (12) has a horseshoe form, and **in that** the ends of the tunnel or conduit extend towards the aft section of the sailboat and further **characterized in that** the movable ballast weight elements are adapted to be displaced independently of each other.

2. The sailboat according to claim 1, wherein the hermetically sealed tunnel or conduit (12) contains a neutral atmosphere, preferably nitrogen.

3. The sailboat according to claim 1, wherein the tunnel or conduit (12) in the hull comprises straight and/or curved segments.

4. The sailboat according to any one of the preceding claims, wherein the tunnel or conduit (12) is provided in the form of a closed loop

5. The sailboat according to any one of the preceding claims, wherein the tunnel or conduit comprises sidewalls provided with a set of rails or tracks for the movable ballast weight elements, and the movable ballast weight elements are provided as a train set.

6. The sailboat according to any one of the preceding claims, wherein the operation of the movable ballast weight elements in the tunnel or conduit (12) is manual.

7. The sailboat according to any one of the preceding claims, wherein the operation of the movable ballast weight elementsin the tunnel or conduit (12) is power-assisted.

8. The sailboat according to any one of the preceding claims, wherein a mechanical force is applied to the movable ballast weight elements.

9. The sailboat according to any one of the preceding claims, wherein the tunnel is built like a cylinder and the ballast weight elements like a two-ended piston and wherein the ballast is actuated by pressurising a gas or a liquid on one of its faces and releasing the gas or the liquid on its other face.

10. The sailboat according to claim 9 wherein the piston has an articulated body allowing it to bend between its two ends.

Patentansprüche

1. Segelboot, das eine bewegliche Ballastanordnung aufweist, wobei die bewegliche Ballastanordnung (11) in einem Tunnel oder Kanal (12) angeordnet ist, der im Inneren und vorzugsweise nahe dem unteren Schiffskörper des Segelbootes vorhanden ist, und das außerdem Ballastgewichtselemente aufweist, die aus Blei bestehen, **dadurch gekennzeichnet, dass** der Tunnel oder Kanal (12) hermetisch abgedichtet ist, dadurch, dass der Tunnel oder Kanal (12) eine Hufeisenform aufweist, und dadurch, dass sich die Enden des Tunnels oder Kanals in Richtung des hinteren Abschnittes des Segelbootes erstrecken, und außerdem **dadurch gekennzeichnet, dass** die beweglichen Ballastgewichtselemente so ausgebildet sind, dass sie unabhängig voneinander verschoben werden können.

2. Segelboot nach Anspruch 1, bei dem der hermetisch abgedichtete Tunnel oder Kanal (12) eine neutrale Atmosphäre enthält, vorzugsweise Stickstoff.

3. Segelboot nach Anspruch 1, bei dem der Tunnel oder Kanal (12) im Schiffskörper gerade und/oder gebogene Segmente aufweist.

4. Segelboot nach einem der vorhergehenden Ansprüche, bei dem der Tunnel oder Kanal (12) in der Form einer geschlossenen Schleife bereitgestellt wird.

5. Segelboot nach einem der vorhergehenden Ansprüche, bei dem der Tunnel oder Kanal Seitenwände aufweist, die mit einem Satz von Schienen oder Laufbahnen für die beweglichen Ballastgewichtselemente versehen sind, und bei dem die beweglichen Ballastgewichtselemente als ein Gruppenverband bereitgestellt werden.

6. Segelboot nach einem der vorhergehenden Ansprüche, bei dem die Betätigung der beweglichen Ballastgewichtselemente im Tunnel oder Kanal (12) manuell erfolgt.

7. Segelboot nach einem der vorhergehenden Ansprüche, bei dem die Betätigung der beweglichen Ballastgewichtselemente im Tunnel oder Kanal (12) servounterstützt erfolgt.

8. Segelboot nach einem der vorhergehenden Ansprüche, bei dem eine mechanische Kraft auf die beweglichen Ballastgewichtselemente angewandt wird.

9. Segelboot nach einem der vorhergehenden Ansprüche, bei dem der Tunnel wie ein Zylinder und die Ballastgewichtselemente wie ein Kolben mit zwei Enden aufgebaut sind, und wobei der Ballast dadurch betätigt wird, dass ein Gas oder eine Flüssigkeit auf einer seiner Seiten unter Druck gesetzt wird und das Gas oder die Flüssigkeit auf seiner anderen Seite freigegeben wird.

10. Segelboot nach Anspruch 9, bei dem der Kolben einen Gelenkkörper aufweist, der ihm gestattet, sich zwischen seinen zwei Enden zu biegen.

Revendications

1. Bateau à voile, comprenant un assemblage de lest mobile, l'assemblage de lest mobile (11) étant agencé dans un tunnel ou un conduit (12) situé à l'intérieur et de préférence près de la coque inférieure dudit bateau à voile, et comprenant en outre des éléments de masse de lestage composés de plomb, **caractérisé en ce que** ledit tunnel ou conduit (12) est fermé de manière hermétique, **en ce que** le tunnel ou le conduit (12) a une forme en fer à cheval, et **en ce que** les extrémités du tunnel ou du conduit s'étendent vers la section arrière du bateau à voile, et **caractérisé en outre en ce que** les éléments de masse de lestage mobiles sont adaptés pour être déplacés indépendamment les uns des autres.

2. Bateau à voile selon la revendication 1, dans lequel le tunnel ou le conduit à fermeture hermétique (12) contient une atmosphère neutre, de préférence de l'azote.

3. Bateau à voile selon la revendication 1, dans lequel le tunnel ou le conduit (12) dans la coque comprend des éléments droits et/ou courbés.

4. Bateau à voile selon l'une quelconque des revendications précédentes, dans lequel le tunnel ou le con-

duit (12) a la forme d'une boucle fermée.

5. Bateau à voile selon l'une quelconque des revendications précédentes, dans lequel le tunnel ou le conduit comprend des parois latérales comportant un ensemble de rails ou de pistes pour les éléments de masse de lestage mobiles, les éléments de masse de lestage mobiles étant agencés en forme de rame.

6. Bateau à voile selon l'une quelconque des revendications précédentes, dans lequel l'actionnement des éléments de masse de lestage mobiles dans le tunnel ou le conduit (12) est manuel.

7. Bateau à voile selon l'une quelconque des revendications précédentes, dans lequel l'actionnement des éléments de masse de lestage mobiles dans le tunnel ou le conduit (12) est assisté.

8. Bateau à voile selon l'une quelconque des revendications précédentes, dans lequel une force mécanique est appliquée aux éléments de masse de lestage mobiles.

9. Bateau à voile selon l'une quelconque des revendications précédentes, dans lequel le tunnel est construit sous forme d'un cylindre, les éléments de masse de lestage étant construits sous forme d'un piston à deux extrémités, le lest étant actionné par mise sous pression d'un gaz ou d'un liquide sur une de ses faces et par dégagement du gaz ou du liquide sur son autre face.

10. Bateau à voile selon la revendication 9, dans lequel le piston a un corps articulé, permettant son fléchissement entre ses deux extrémités.

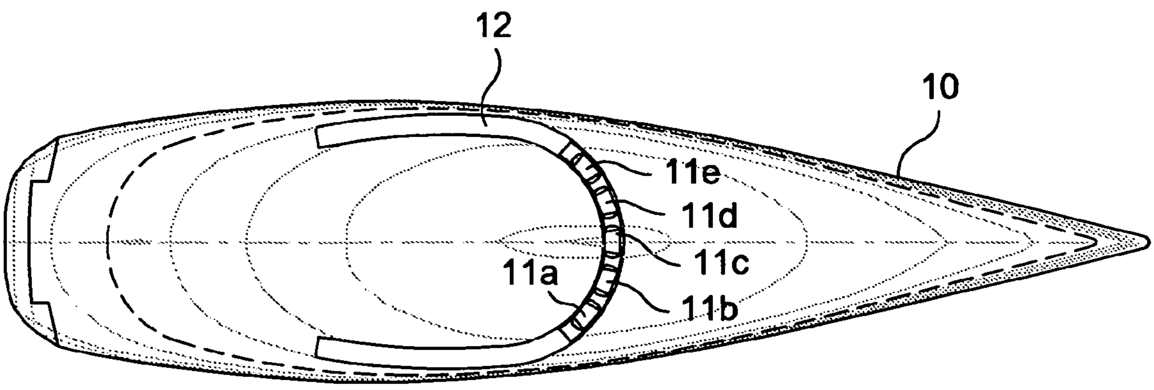


Fig. 1

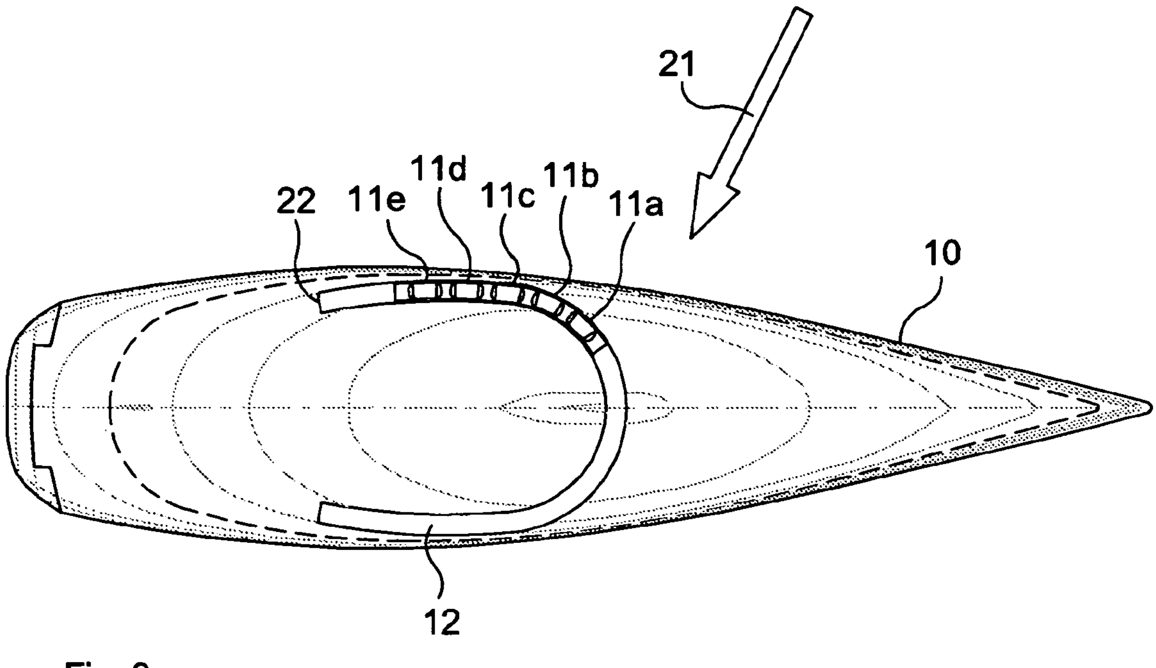


Fig. 2

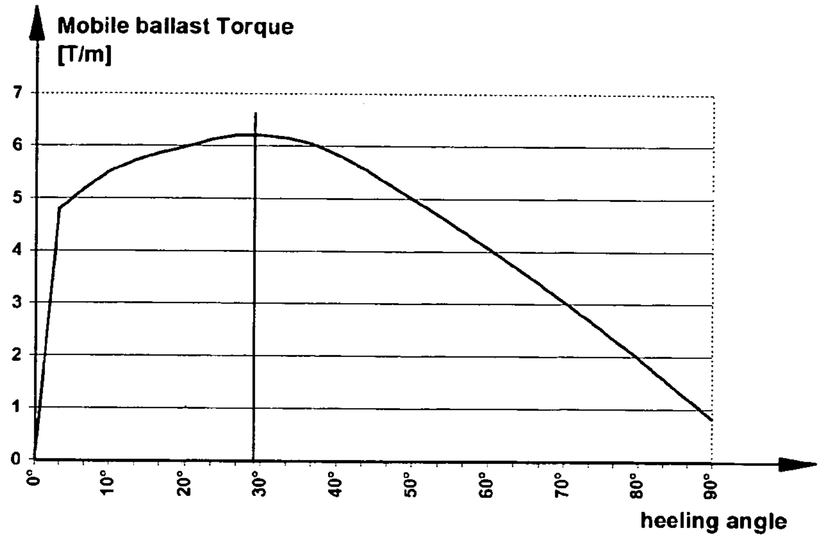
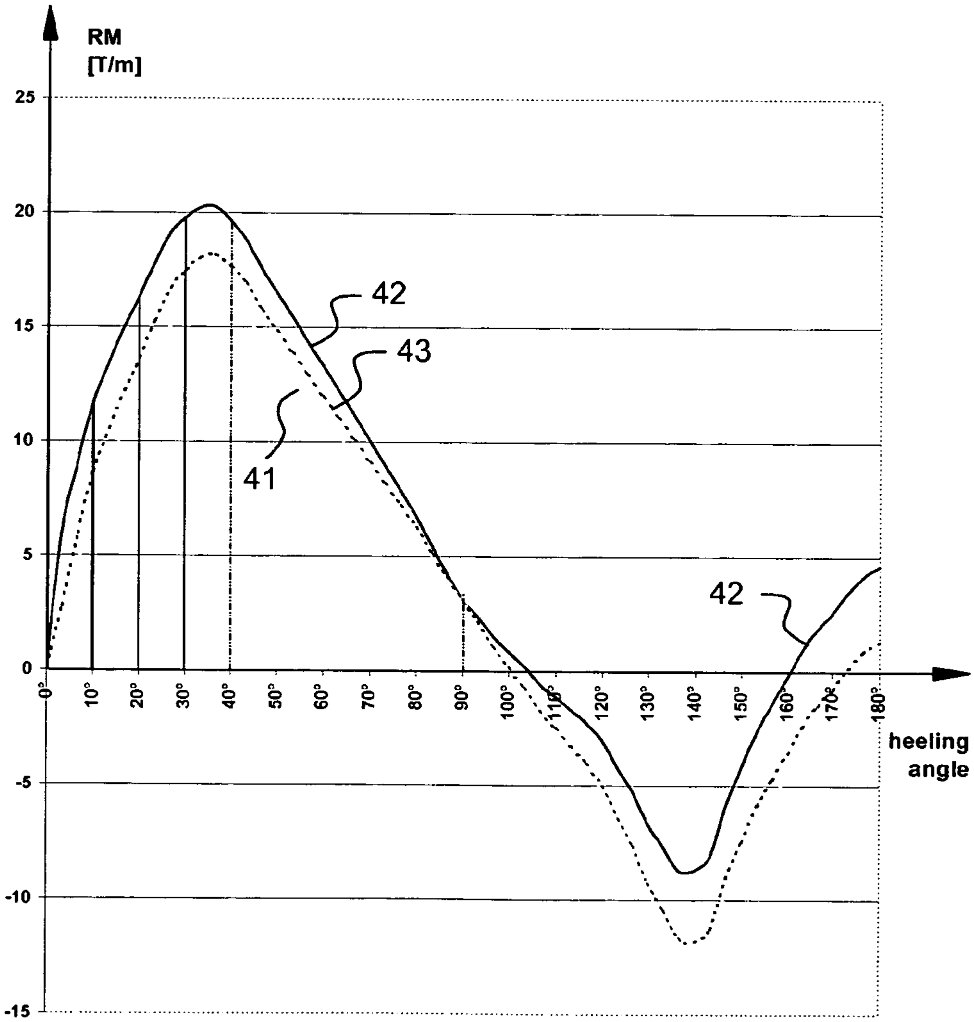

Mobile ballast Torque
[T/m]
7
6
5
4
3
2
1
0
0°
10°
20°
30°
40°
50°
60°
70°
80°
90°
heeling angle

Fig. 3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10
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-15
42
43
41
42
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20°
30°
40°
50°
60°
70°
80°
90°
100°
110°
120°
130°
140°
150°
160°
170°
180°
heeling angle

Fig. 4

REFERENCES CITED IN THE DESCRIPTION

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