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SHIP HAVING AN AIR CUSHION UNDER THE BOTTOM

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2 Sheets-Sheet 1

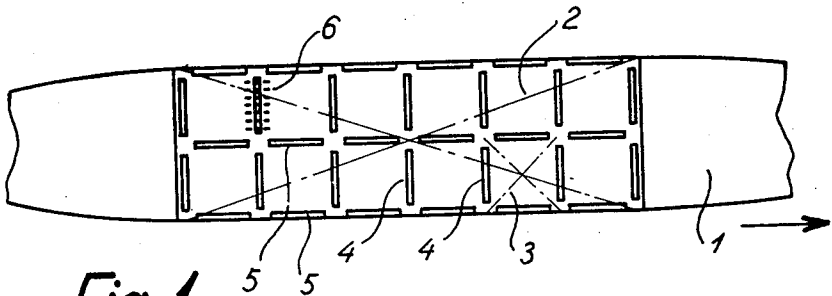


Fig. 1

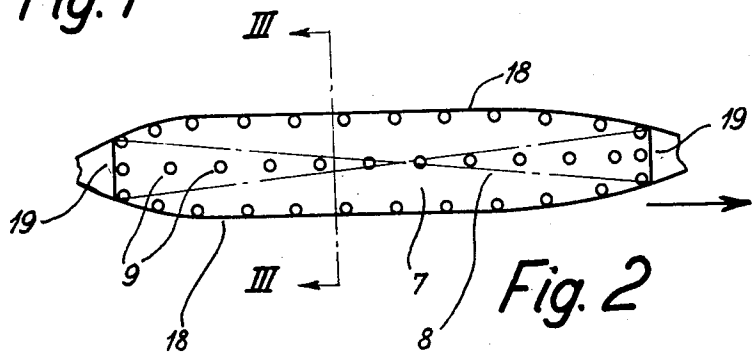


Fig. 2

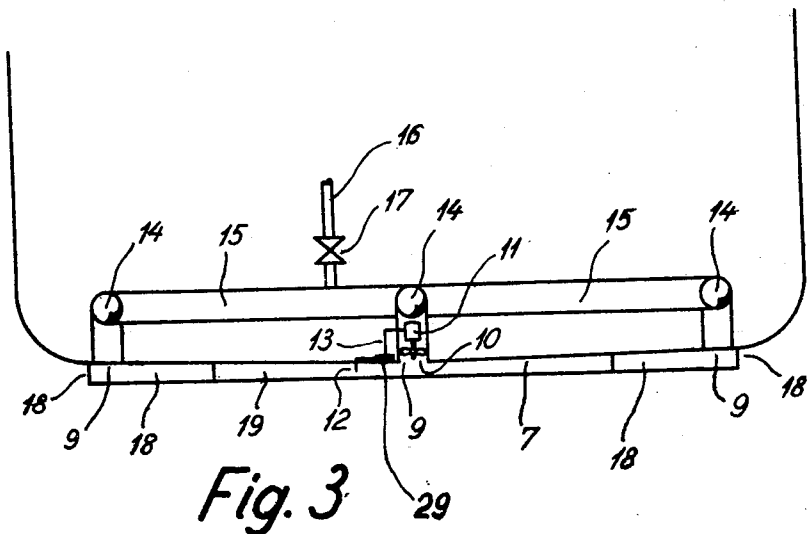


Fig. 3

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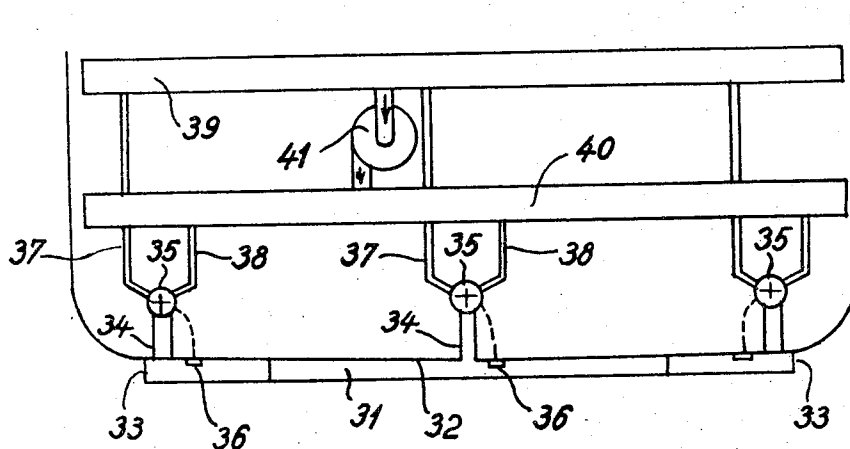
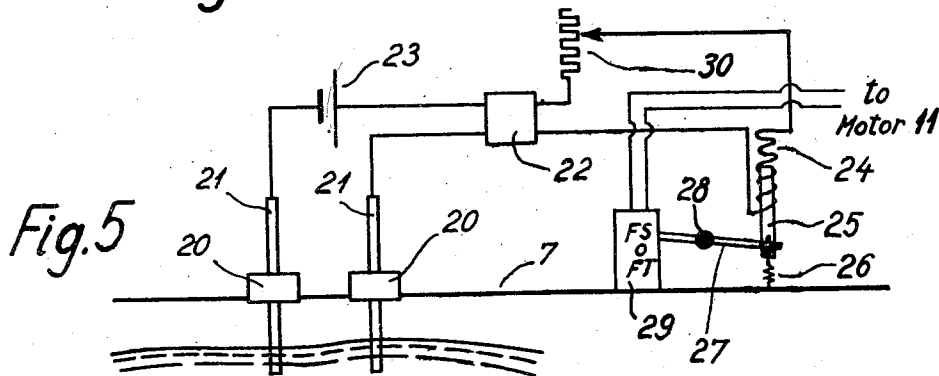
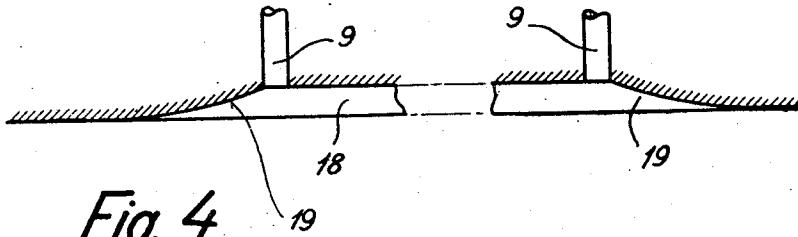
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SHIP HAVING AN AIR CUSHION UNDER THE BOTTOM

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The invention relates to a ship having an air cushion 10 under the bottom.

Air cushion ships of this kind with a longitudinal air circuit adapted to correct for the forward motion of the ship and for pitching, and with a transverse circuit adapted to correct for rolling, are known. By a ship of this kind there will at a fixed moment be a constant longitudinal air velocity all over the air cushion, and likewise a constant transverse air velocity all over the air cushion. As the pressure gradient in the air in a fixed direction is a function only of the air velocity in this direction, the longitudinal pressure gradient and as well the transverse pressure gradient will be the same in all the points of the air cushion. Herefrom follows that the pressure surface of the air will be plane, the pressure surface being defined as the surface produced by plotting the air pressures vertically from a horizontal base plane.

If the air cushion shall be stable, the pressure surface of the air must be coincident with the pressure surface of the water, the pressure surface of the water being defined as the surface produced by plotting vertically from the said horizontal base plane the water pressures against the bottom of a corresponding ship without air cushion. This condition can also be expressed so that the isobar surfaces of the water under the ships bottom shall be plane all over the area of the air cushion, but this is correct only in very few cases, e.g. by slow ships sailing in still water, or small and slow ships sailing in waters with relatively very large waves.

In most cases in practice the isobar surfaces of the water will be very wavy, wherefrom follows that the air cushion will be collapsed over large areas while at other places the air cushion will project down under its side limitations so that air losses will occur. Experiments and calculations have shown that side keels of two meters depth should be used to bound the air cushion under a 10,000 tons d.w. ship sailing in a rough sea in the Atlantic. Hereby, however, there will be added a rather large skin friction against the outer faces of the side keels, and in addition hereto the power consumption necessary to circulate the air in a longitudinal and transverse direction is considerably increased.

The object of the invention is to provide means of adjusting the air pressures to the water pressures so that the air cushion can be maintained as a plane layer substantially parallel to the flat bottom of the ship over a major portion thereof.

A further object of the present invention is to provide an air cushion of minimum thickness, to reduce the height of the necessary side keels. If the bottom is divided up into an infinite number of sections, a perfect plane-parallel air cushion of any small thickness will be obtainable. The largest dimension of a section ought to be less than the half of the minimum occurring wave length of the waves met by a ship. In these shall be included both the waves produced by the ship itself and alien waves.

A simple and practical embodiment of an air cushion plant with such division into sections is according to the invention characterized by an air reservoir situated above the bottom and being in connection with the air cushion through a number of openings or tubes evenly distributed over the area of the air cushion, each opening or tube containing a reversible and adjustable blower which by

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means of a feeler adapted to record the air cushion thickness at the place in question is so governed that it carries air from the reservoir to the air cushion when the air cushion thickness is less than normal, and from the air cushion to the reservoir when the air cushion thickness is greater than normal.

If the pressure changes take place so rapidly that the blowers cannot manage to be accelerated, decelerated or reversed fast enough, another embodiment may be used, this embodiment being according to the invention characterized in that the air cushion through a number of openings or tubes evenly distributed over its area is in connection partly with an air reservoir with higher pressure than the air cushion and partly with an air reservoir with lower pressure than the air cushion, each opening or tube containing a closing member which by means of a feeler adapted to record the air cushion thickness at the place in question is so governed that air is carried from the high pressure reservoir to the air cushion when the air cushion thickness is less than normal, and from the air cushion to the low pressure reservoir when the air cushion thickness is greater than normal. This device will be faster working during the pressure changes, there being no blowers to be reversed, accelerated or decelerated. There may be arranged a blower continuously sucking from the low pressure reservoir and delivering to the high pressure reservoir.

The feeler adapted to record the air cushion thickness and govern the blower motor or the closing member must be simple and reliable, and it may therefore according to the invention consist of a pair of electrodes penetrating the air cushion and being immersed into the water, the electrodes being included in an electrical circuit fed by a source of electricity and adapted to influence an electromagnetic mechanism in dependence on the amperage, the electromagnetic mechanism being adapted to adjust automatically the regulator of the blower motor or the closing member, respectively. The electromagnetic mechanism must be able to serve the complete field of regulation, i.e. the entire field from the highest positive to the highest negative speed of the blower (pressure and suction, respectively), or the entire field of regulation extending from full opened closing member to the high pressure reservoir to full opened closing member to the low pressure reservoir (simultaneously with shut closing member to the high pressure reservoir).

It will be possible to adjust the air cushion thickness at which air is neither supplied to or removed from the air cushion at the place of each feeler unit, if according to the invention a variable resistance is included in the electrical circuit or in a corresponding amplifier circuit. By a given water level, i.e. a given resistance in the salt water between the electrodes, it is possible by adjustment of the variable resistance to regulate the position of the blower regulator or the closing members, respectively, until the zero position is obtained.

The air cushion plant described in the foregoing will operate perfectly only if the air cushion has the correct degree of filling. If the air cushion becomes too thick, the blowers will not have sufficient power to obtain sufficiently large air velocities, and if the air cushion becomes too thin, the risk may occur that large areas of the bottom become wetted. In order to maintain the correct air cushion thickness a compressor for delivering compressed atmospheric air to the air cushion may according to the invention be governed by a feeler electrode of the same kind as described in the foregoing. This compressor must be of a kind capable of delivering air to the air cushion as well as removing surplus air from the air cushion by opposite direction of rotation, as it may well be possible that the air cushion becomes too thick e.g. by rises of temperature. The automatic means must in this case

operate some more sluggishly than in case of the blowers, because it may be expected that an air cushion being stable for that matter will oscillate a little in thickness all the time. The air cushion thickness is adjusted by varying the resistance in the circuit of the feeler electrode of the compressor, and in dependence hereon the zero positions of the feeler electrodes of the blowers of the blowers are adjusted.

In this way the entire plant will be automatically working and thus will not require manual control.

In the drawing is shown some embodiments of air cushion ships according to the invention together with some details of the air cushion plants.

FIG. 1 is a partial view of an air cushion ship seen from the bottom,

FIG. 2 is a partial view of another air cushion ship, also seen from the bottom,

FIG. 3 is an enlarged section along the line III—III in FIG. 2,

FIG. 4 is a vertical longitudinal section through the bottom of an air cushion ship,

FIG. 5 schematically shows a feeler to be used in connection with the embodiment shown in FIG. 3.

FIG. 6 shows a modification.

The ship shown in FIG. 1 has a flat bottom 1 which in the area of the parallel middle body is provided with an air cushion indicated by a diagonal cross 2 in chain-dotted lines. The air cushion area is divided up into twelve square sections, one of these being marked with a diagonal cross 3 in chain-dotted lines. At the fore and aft edge of each section is provided a transverse slot 4 in the bottom 1. Likewise, each section has along the starboard edge and port edge a slot 5 in the bottom. To avoid the weakening of the bottom plates on account of the transverse slots 4 a row of longitudinal flat irons 6 may be placed across these slots, the flat irons being welded to the bottom plate on each side of the slot 4. Each section has a transverse air circuit connected with the slots 5 and a longitudinal air circuit connected with the slots 4. The two air circuits in each section have a forced circulation by means of blowers, not shown. In each section the longitudinal and transverse air velocity is so adjusted that the boundary face between water and air as far as possible will be parallel to the bottom 1 over the area of the section.

The air cushion ship shown in FIG. 2 has a flat bottom 7 with an extensive air cushion area marked with a diagonal cross 8 in chain-dotted lines. Into the bottom debouch a number of tubes 9 being evenly distributed over the area of the air cushion. In each tube 9 is mounted an adjustable and reversible screw blower 10, see FIG. 3, being driven by a motor 11 governed by a feeler 12 which shall be described more in detail in the following. The feeler 12 is connected with the motor 11 by means of electric wires 13.

Each of the tubes 9 is at the top connected airtight with an air reservoir consisting of three longitudinal tubes 14 and any number of transverse tubes 15. To this air reservoir is connected a compressor pipe 16 with a stop valve 17.

The air cushion itself is at the sides bounded by side keels 18 and fore and aft by a step 19 in the bottom 7. The steps 19 have the shape shown in FIG. 4 so that they do not offer too large a pressure resistance for the water. It must be expected, namely, that the water surface will oscillate up and down along the steps 19 during the presumably inevitable small oscillations of the water surface at the fore and aft edge of the air cushion.

In FIG. 5 is schematically shown the automatic means of governing one of the motors 11 in FIG. 3. In the bottom are fitted two insulating plugs 20 being each provided with an electrode 21 immersed into the water under the air cushion. An electric circuit fed by a source of electricity 23 passes through the electrodes 21 and the salt water between them and through an amplifier 22.

The current taken out from the amplifier 22 passes through a variable resistance 30 and a magnet coil 24 able to attract an iron core 25 which at the lower end is acted upon by a tension spring 26. An arm 27 is inserted between two lateral pins in the lower end of the iron core 25 and is fastened on a shaft 28 being connected with the regulator 29 of the blower motor, the regulator being able to regulate the motor from highest positive to highest negative speed. In the shown position FS of the arm 27 the blower is sucking with full power from the air cushion corresponding to low water level, i.e. large air cushion thickness. By rising water level, i.e. decreasing air cushion thickness, the arm 27, through the position O in which the motor speed is zero, will reach the position FT in which the blower with full power is delivering air to the air cushion corresponding to minimum or even zero air cushion thickness.

The electrodes 21 are not situated opposite the tube 9, as the water level will in this area be acted upon by the velocity pressure of the air stream, but a little beside the tube as shown in FIG. 3.

The degree of filling of the air cushion is governed by a compressor connected with the compressor pipe 16 and adapted to suck from the atmosphere and deliver air to the air cushion or, by opposite direction of rotation, carry air from the air cushion to the atmosphere. This compressor is governed by like feeler electrodes as shown in FIG. 5 whereby it will be able to maintain a constant air cushion thickness or rather mean thickness of the air cushion. If the air cushion thickness at the point of the air cushion shown in FIG. 5 is equal to the said mean thickness, the arm 27 will be in the position O in which the blower is at rest.

It should be noted that the means shown in FIGS. 2, 3 and 5 of stabilizing the air cushion also cooperate to compensate for the deflection of the air cushion due to the speed of the ship through water, because the means will counteract the tendency of the air to pack together in the aft part of the cushion on account of the friction from the water. However, only the foremost and the aftermost blowers will participate in this action, and for this reason there must be provided more or larger blowers in the foremost and aftermost end of the air cushion than in the other parts of the air cushion. This will be apparent from FIG. 2.

Each tube 9 with blower 10, motor 11, feeler 12 and wires 13 can be produced as a separate, interchangeable unit.

In FIG. 6 is shown a partial section of an air lubricated ship according to another embodiment of the invention. The air chamber 31 is enclosed by the bottom 32 and two side keels 33. Evenly distributed over the flat bottom 32 is a number of pipes 34 each leading to a three-way cock 35 wherefrom two pipes 37 and 38 are leading to a low-pressure reservoir 39 and a high-pressure reservoir 40, respectively. The pressures in the reservoirs 39 and 40 are lower and higher, respectively, than any pressure existing in any point of the air chamber 31. A blower 41 is continuously sucking from the low-pressure reservoir 39 and delivering to the high-pressure reservoir 40. The parts 34, 35, 37, 38, 39, 40 and 41 are hermetically sealed from the atmosphere.

Each pipe 34 has a nearby feeler 36 operatively connected to the corresponding three-way cock 35 in such a way that air is transferred from the air cushion to the low-pressure reservoir 39 via pipes 34 and 37, when the feeler 36 is sensing a thickness greater than a predetermined one. On the other hand, air is transferred from the high-pressure reservoir 40 to the air cushion via pipes 38 and 34 and cock 35, when the feeler 36 is sensing a thickness less than a predetermined one, and has turned cock 35 accordingly. The plant according to FIG. 6 will react faster on pressure variations than the one shown in FIG. 3.

I claim:

1. In a ship, in combination, a ship's bottom formed with a downwardly open chamber adapted to contain an air cushion of predetermined thickness and extending over a major portion of said bottom, and a plurality of means communicating with said chamber respectively at a plurality of locations evenly distributed over the entire area of the bottom for delivering air to any of said locations where the thickness of said air cushion decreases below said predetermined thickness, said means including a plurality of air transfer means for delivering air to any of said locations, a plurality of feeler means each coordinated with one of said air transfer means for sensing the thickness of said air layer in the region of said location, respectively, and a plurality of regulating means each operatively connected to one of said air transfer means and said feeler means coordinated thereto for controlling said air transfer means so that air is delivered by said air transfer means to any of said locations where

the thickness of the air cushion decreases during operation of the ship below said predetermined thickness.

2. An arrangement as defined in claim 1 in which each separate air transfer means is also adapted to suck air from the air cushion at the corresponding location, when the thickness of said air cushion, sensed by the adjacent feeler unit, increases beyond a predetermined value and thus adjust the corresponding regulating means accordingly.

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