PUBLISHED

MAY 11, 1943.

BY A. P. C.

H. HORT

METHOD AND ADVICES FOR VARYING THE STABILITY OF A SHIP

Filed March 24, 1937

Serial No. 132,695

4 Sheets-Sheet 1

Fig. 1

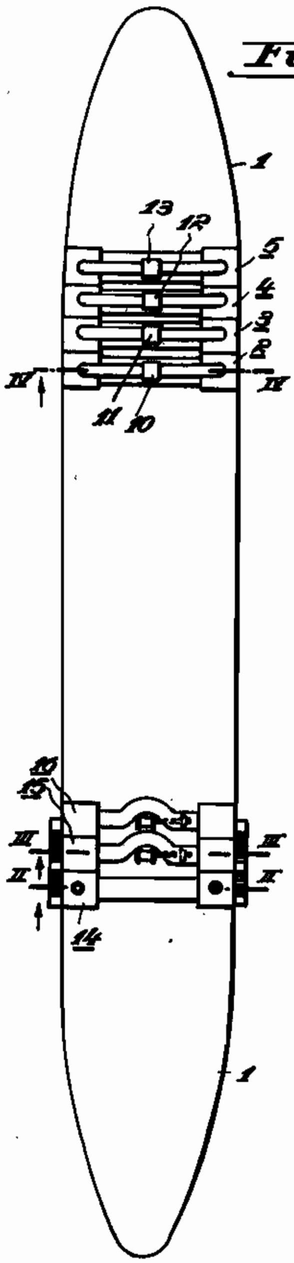


Fig. 4

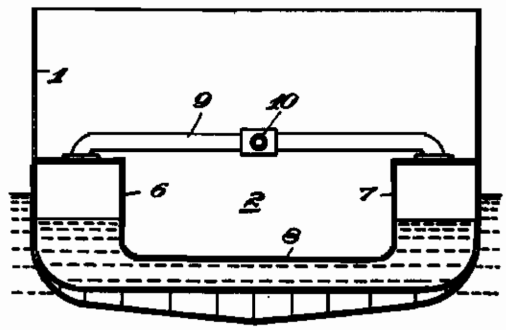


Fig. 3

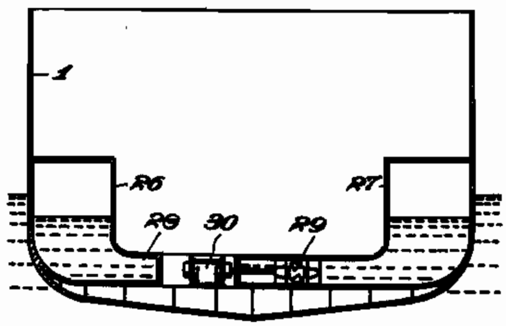
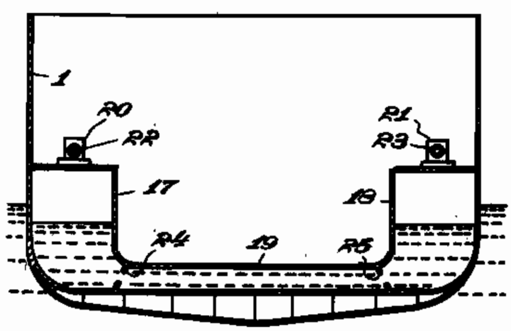


Fig. 2



Inventor

Hermann Hort

by Knight Bros

Attorneys

PUBLISHED

MAY 11, 1943.

BY A. P. C.

H. HORT

METHOD AND ADVICES FOR VARYING THE STABILITY OF A SHIP

Filed March 24, 1937

Serial No. 132,695

4 Sheets-Sheet 2

Fig. 5

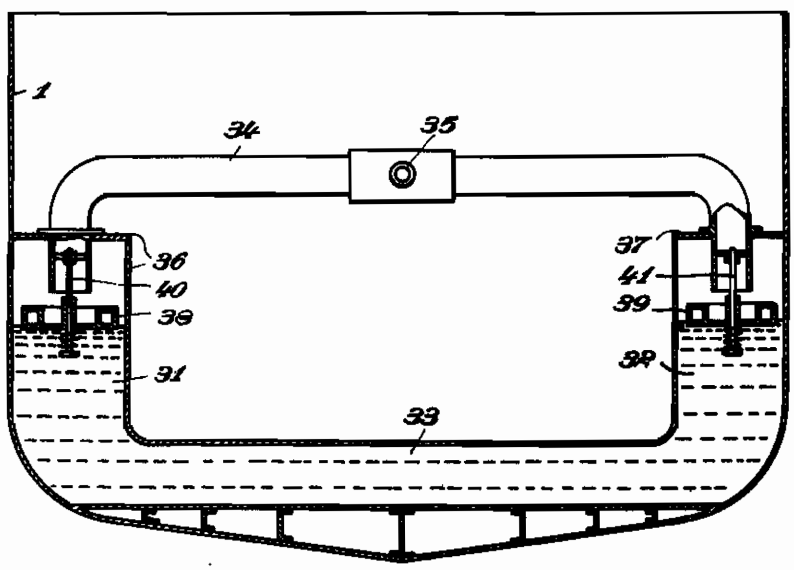
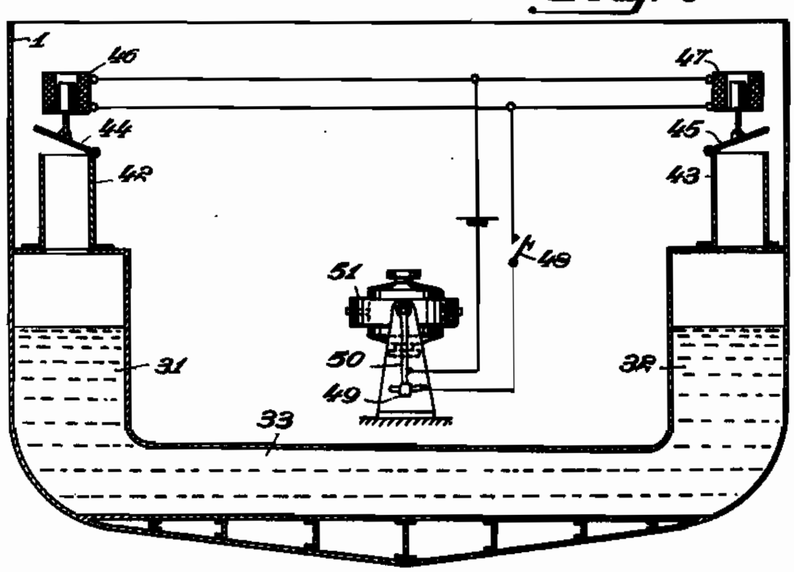


Fig. 6



Inventor
Hermann Hort
by Knight Bros
Attorneys

PUBLISHED
MAY 11, 1943.
BY A. P. C.

H. HORT
METHOD AND ADVICES FOR VARYING
THE STABILITY OF A SHIP
Filed March 24, 1937

Serial No.
132,695
4 Sheets-Sheet 3

Fig. 7

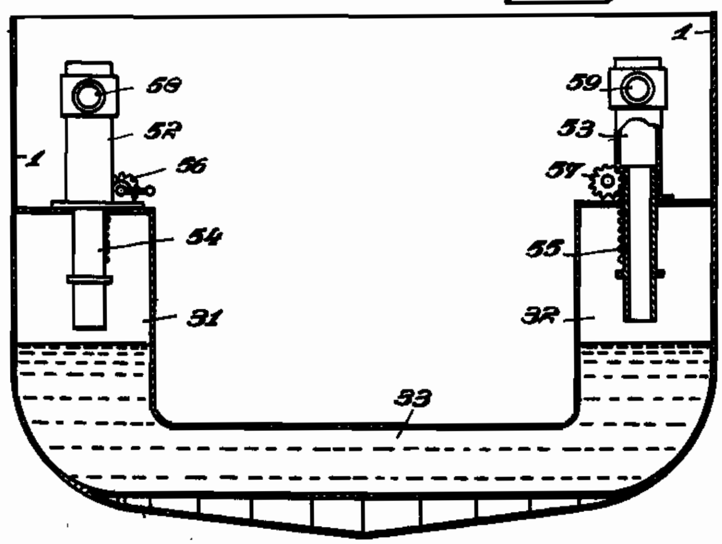
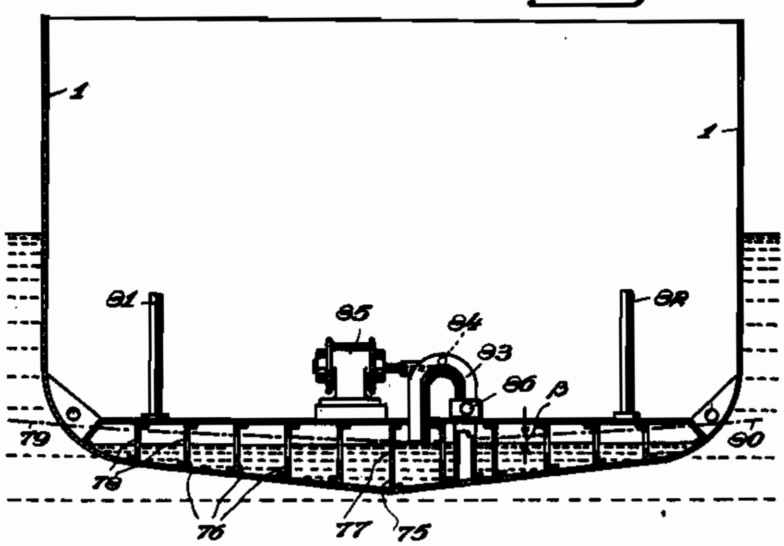


Fig. 10



Inventor
Hermann Hort
by Knight Bros
Attorneys

PUBLISHED

MAY 11, 1943.

BY A. P. C.

H. HORT

METHOD AND ADVICES FOR VARYING THE STABILITY OF A SHIP

Filed March 24, 1937

Serial No. 132,695

4 Sheets-Sheet 4

Fig. 8

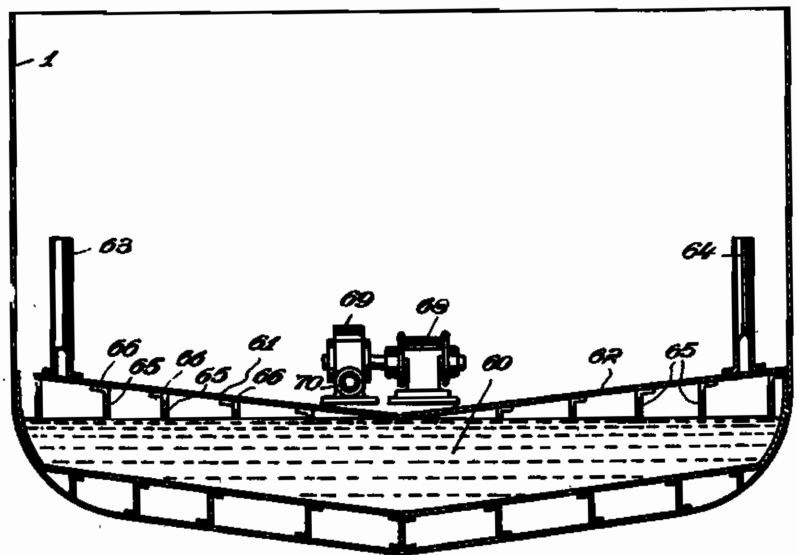
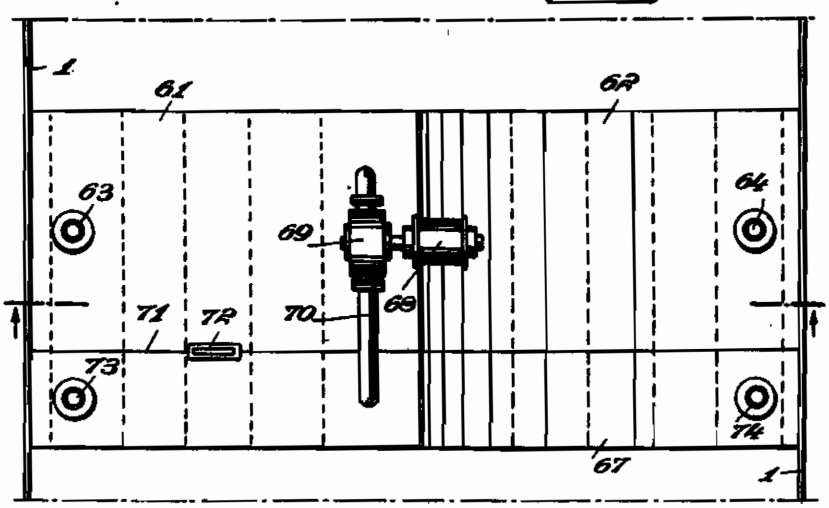


Fig. 9



Inventor

Hermann Hort

by Knight Bros

Attorneys

Published May 11, 1943 Serial No. 132,695

ALIEN PROPERTY CUSTODIAN

METHOD AND ADVICES FOR VARYING THE STABILITY OF A SHIP

Hermann Hort, Berlin-Charlottenburg, Germany; vested in the Alien Property Custodian

Application filed March 24, 1937

My invention relates to a method and arrangements for controlling the stability of a ship.

The oscillation generating effect of the wave motion on a ship is, as is well known, the more effectively counteracted, the more the period of oscillation of the ship differs from the period of oscillation of the relative wave motion. In the most simplest manner, the period of oscillation of a ship may be influenced by varying the metacentric height by means of liquid tanks. If the ship has a small metacentric height, also the sea can exert only correspondingly small turning moments on the ship; furthermore, there is practically no resonance between the oscillation of the ship and the wave motion owing to the long period of oscillation of the ship. However, with decreasing metacentric height, also the stability of the ship decreases.

By reason of this fact it has been proposed to give, on the one hand, the ships a small metacentric height in order to reduce the oscillation generating effect of the wave motion and on the other hand, by designing the ship in a corresponding manner, to arrange that with increasing list of the ship, the stability thereof is increased again.

The ship stabilizing arrangement according to the invention is characterized by a tank arrangement for varying the metacentric height at which the motion of the tank liquid has a phase displacement of 0° with respect to the oscillation of the ship.

The stabilization may be effected by a corresponding variation of the oscillation of the ship with respect to the period of oscillation of the relative wave motion by putting into and out of operation the tank arrangement which may consist of one or more units. However, the arrangement may also be so designed that with a tank in operation, the metacentric height amounts exactly or approximately to zero; in the case of a danger, the metacentric height increases owing to the fact that the motion of the liquid is prevented, for instance, by filling up the tank with liquid.

The motion of the liquid may also be interrupted, as hereinafter described, by other means as well as automatically.

Consequently, to vary the metacentric height of the ship, the so-called principle of the "free surfaces" is taken advantage of. In connection with the application of this principle, means are, however, employed at the same time, by means of which the danger is eliminated which might occur when applying this principle. To this end, as above described, the tank arrangement operating according to the principle of the "free surfaces" may be subdivided into various units which may separately be put into and out of operation. By the subdivision of the tank arrangement into the above-mentioned units besides the reliable control of the motion of the tank liquid also the advantage is obtained that the metacentric height may be gradually varied and, therefore, the period of oscillation of the ship may be adjusted (gradually) to any values within certain limits.

Furthermore, the tanks for varying the metacentric height are provided according to the invention with means for automatically interrupting the motion of the tank liquid upon the attainment of a given angle of inclination, for instance, of 3 to 4°. Such means consist according to the invention, for instance, in the selection of a corresponding distance between the mouth of an air inlet and outlet conduit and the tank liquid level.

In the accompanying drawings are shown some embodiments of my invention in diagrammatic form.

Fig. 1 is a top view of a ship with a tank arrangement according to the invention for varying the period of oscillation of the ship.

Fig. 2 is a cross section on the line II—II of Fig. 1.

Fig. 3 is a cross section on the line III—III of Fig. 1.

Fig. 4 is a cross section on the line IV—IV of Fig. 1.

Fig. 5 shows one embodiment of my invention.

Fig. 6 shows a modification of my invention.

Fig. 7 shows another modification of the tank arrangements according to the invention provided with means for automatically interrupting the motion of the liquid.

Fig. 8 is a cross section of another modification according to the invention.

Fig. 9 is a top view thereof.

Fig. 10 shows another modification of my invention.

To vary the period of oscillation of the ship, the metacentric height is varied in the embodiment shown in Figs. 1 to 4 with the aid of four tank groups 2, 3, 4 and 5 accommodated in the front half of the ship 1. Each tank group consists, as indicated in Fig. 4 in connection with the tank group 2 shown in cross section, of two tanks 6 and 7 arranged at opposite sides of the ship and communicating with one another through a liquid transverse channel 8 and an air transverse channel 9. In the air channel 9 is arranged a shut-off device 10. The sectional area of flow of the liquid channel 8 and of the air channel 9 is so amply dimensioned that when the shut-off device 10 is opened to the full extent the phase displacement is zero between the motion of the tank liquid and the motion of the ship.

For a better understanding of the operation of the tank group, it is at first assumed that the air channel 9 is omitted and that both tanks 6 and 7 are open at the top and that a shut-off device is provided in the water channel 8. (Such an arrangement would also be possible in practice and is within the scope of the invention). If the above-mentioned shut-off device 8 in the water channel is closed, it is natural that the tank liquid is almost rigidly coupled with the ship, i. e., it forms a portion of the ship body and increases the metacentric height as compared to the case in which there would not be any liquid.

If the above-mentioned shut-off device in the channel 8 is, however, in the open position, the tank liquid, as above described, does not participate in the motion of the ship in the case of a sufficiently large cross-sectional area of the channel 8, i. e., it behaves as if it were a portion of the sea water; in other words, the tank liquid forms free surfaces in the ship. That means that in the case of an open shut-off device the metacentric height of the ship is smaller than if it were closed.

The shut-off device when arranged in the liquid channel 8 would have relatively large dimensions. The dimensions of the shut-off device may be considerably reduced if, as shown in Figs. 1 and 4, both tank halves are closed at the top and connected with one another through an air channel 9 and if the shut-off device 10 is arranged in this air channel. The operation, however, is substantially the same as in the above-described case.

In short, by opening and closing the shut-off device 10, the metacentric height and, therefore, the period of oscillation of the ship may, consequently, be varied. Depending upon the desired range within which the period of oscillation of the ship is to be varied, one or more, for instance four tank groups are provided which will now be described with reference to Fig. 4.

As above described, it was considered that the shut-off device 10 is completely opened or completely closed. The shut-off device may also be brought into a position lying between these two end positions with the result that the tank group in question operates subsequently as a passive anti-rolling tank. This is of importance in connection with the following case: As already mentioned, the period of oscillation of the ship may, of course, be only varied within certain limits with the aid of the shown or similar auxiliary means.

It is assumed that the period of oscillation of the ship in the case considered lies above the period of oscillation of the relative wave motion and that the last-mentioned period of oscillation varies to such an extent as to approach the period of oscillation of the ship. It is possible to increase the period of oscillation of the ship by a corresponding adjustment of the tank groups 2—5 and to evade in this manner the period of oscillation of the relative wave motion. If, however, the period of oscillation of the relative wave motion is increased, it is then necessary according to the invention to reduce again the period of oscillation of the ship. In this case, when regulating the range of resonance must be traversed with the result that the ship may temporarily be rolled to a great extent. To keep the amplitude of the oscillation in this case within reasonable limits, preferably one or more of the tank groups 2 to 5 serving to vary the metacentric height of the ship are at first all temporarily adjusted as anti-rolling tanks and then, as the case may be, as detuning tanks (since, as already described, the period of oscillation of the ship is varied by the last-mentioned tanks, these tanks will be hereinafter referred to as detuning tanks) and the variation of the adjustment of the valves 10, 11 etc. necessary to vary the period of oscillation of the ship with respect to the period of oscillation of the relative wave motion will gradually be effected or at first all tank groups 2 to 5 will be employed as rolling tanks and then as detuning tanks in order to vary the period of oscillation of the ship.

In one embodiment, the tanks may also be so dimensioned as to permit a reduction of the metacentric height of the ship to zero or approximately to zero so that the ship will be unstable or has a very long period of oscillation. In this embodiment, a further advantage may be obtained according to the invention by dimensioning the sectional area of flow of the tank groups 2 to 5 in such a manner that when the shut-off devices 10 to 13 are opened to the full extent, the phase displacement will be zero only in the case of the above-mentioned long oscillations of the ship, but that a phase displacement of approximately 90° occurs automatically, if the ship for any reasons whatever carries out shorter oscillations. That implies so to say a safety device which is switched in automatically, insofar as in the case of more rapid oscillations of the ship, the tank group or groups in question are converted into passive anti-rolling tanks.

Under circumstances, also a particular anti-rolling arrangement 14, also effective for long periods of oscillations of the ship, may be provided and may be designed in the form of a passive or also of a controlled arrangement, if necessary, equipped with an activating drive, such as a motor-driven propeller, blower or the like. In Fig. 2 which shows a cut through the tank group 14 of Fig. 1 acting as an anti-rolling arrangement is shown a passive tank group having two tanks 17 and 18 communicating with one another through a water transverse channel 19. Both tanks 17 and 18 communicate at the top with the outside atmosphere through a connecting branch 20 and 21 respectively. In each branch is arranged an adjustable shut-off device 22 and 23 respectively. By these devices the throttling may be adjusted to the desired degree and, therefore, the desired phase displacement between the oscillation of the ship and the oscillation of the tank liquid within the limits determined by the tank group. Furthermore, the water channel 19 may be throttled, for instance, as indicated at 24 and 25.

Finally, an arrangement is provided for preventing the ship from getting into a static inclined position consisting in the embodiment shown of two sets 15 and 16 (Fig. 1) or an arrangement serving to bring the ship into the upright position in the case of an unstable ship.

Each set consists, as will be seen from the cut through the set 15 shown in Fig. 3, of two tanks 26 and 27 arranged at both sides of the ship and communicating with one another through a liquid channel 28. In the liquid channel is provided a propeller 29 operatively connected with a motor 30 and serving as an activating drive. To enable a reversal of the direction of displacement of the tank water between backboard and starboard and vice versa, the propeller 29 may be designed in the form of a controllable propeller or also the driving motor 30 in the form of a reversing motor. The control is effected through a control device which determines the statical inclined position of the ship. As to the particular design of the control device reference may be had to the device described in the German patent 630,637 or in the British patent 458,616.

The tank group may also be operated automatically if it is the case of adjusting the tank group with respect to the period of oscillation of the ship to be determined continuously, for instance, by time measurements. To this end, the period of oscillation of the relative wave motion may be determined, for instance, with the aid of a calculating device to which the direction of travel of the ship relatively to the wave motion, the speed and further the period of oscillation or the length of the period of the wave motion determined by a subjective or objective observation are transmitted. By means of a member whose position is a measure for the above-mentioned magnitude, a follow-up motor or the like is adjusted which in turn adjusts within given limits the period of oscillation of the ship to the greatest possible departure from the period of oscillation of the relative wave motion. The tank group may also be operated by hand in accordance with the period of oscillation of the relative wave motion determined in the above-mentioned manner and with the period of oscillation of the ship, also determined as above described.

Tele-indicating systems are preferably employed which indicate the positions of the shut-off devices 10 to 13 on the conning bridge and under circumstances at other points so that the signals necessary in carrying out the method according to the invention may be transmitted from the above-mentioned points.

To reduce the costs of the installation, it is advisable to use at the same time the tanks required for the liquids, for instance, the fuel tanks etc., for the purposes under consideration, i. e., to design these tanks in such a manner as shown in Figs. 2 to 4.

In order to rapidly neutralize the kinetic forces of flow in the detuning tanks, either viscous liquids having a great inner friction are to be employed or perforated plates of sheet iron or the like are to be arranged in the path of the flowing liquid. Under circumstances, also the free surfaces of the tanks are to be covered with suitable damping means; for instance, viscous liquids or floating bodies.

Figs. 5 to 10 show embodiments of tank arrangements for varying the period of oscillation of the ship which are provided with means for automatically interrupting the motion of the tank liquid. The arrangement is preferably designed in such a manner that the metacentric height in the case of a free movement of the liquid, that is in the case of a free surface, has a small value; for instance the zero value. This metacentric height is automatically increased by influencing the tank arrangement if a certain list angle of the ship is exceeded. The invention relates both to the case in which the metacentric height increases suddenly upon exceeding a predetermined list and to the case in which the metacentric height increases, under circumstances, steadily with increasing list.

Fig. 5 shows a tank arrangement corresponding to that of Fig. 4. The tank group consists of two tanks 31 and 32 arranged at both sides of the ship 1 and connected with one another through the water channel 33 and the air channel 34 in which a shut-off device 35 is provided.

The operation of this tank arrangement is exactly the same as that described in connection with Fig. 4. The tank liquid forms, when the shut-off device 35 is closed, a portion of the ship body, and the metacentric height is increased, whereas when the shut-off device is open the tank liquid forms a free surface in the ship and the metacentric height is reduced. Consequently, the metacentric height may be alternately increased or reduced.

The invention may also be carried into practice as shown in Fig. 5 in the manner that the ends of the air pipe 34 do not terminate at the tops of the tanks 31 and 32 but project into the same and end at a point which is so high above the tank liquid level that the tank liquid enters the air pipe 34 at an inclined position of the ship of a given magnitude, say, of 3° to 4°. In this manner, such a throttling is brought about that the property of the tank liquid to form a "free surface" is lost with the result that the metacentric height of the ship increases automatically. A similar effect is, therefore, brought about automatically as if the shut-off device 35 were being closed. By varying the contents of the tank arrangement, the angular value may be varied, at which the metacentric height increases. Such a variation may be obtained by means of the embodiment shown in Fig. 7, even without varying the tank liquid.

The effect above-described would, of course, also be brought about if the air pipe 34 would end at the top of the tanks 31 and 32 and if the distance between the liquid level and the covers 35, 37 of both tanks were chosen in accordance with the above-described forms of invention. However, in this case powerful impacts would be exerted on the covers of the tanks 31 and 32 by the tank liquid. This is prevented if as shown in Fig. 5 the ends of the air transverse pipe 34 project into the tanks 31, 32; for in this case, as soon as the level of the tank liquid reaches the end of the air transverse pipe 34, an air pad acting in the form of an air dashpot is enclosed between the tank cover 36 or 37 and the end of the air transverse pipe, and prevents the impacts of the tank liquid on the tank cover.

As shown in Fig. 5, floats 38 and 39 are provided according to the invention and are so guided along rods 40 and 41 secured to the air transverse channel 34 that upon exceeding a given list of the ship, the air transverse channel is closed at the inclined side of the ship. In this manner, the above-mentioned effect is still increased and at the same time water is prevented from entering the air transverse channel. It is advisable to support the floats 38 and 39 by springs.

In the embodiment shown in Fig. 6, both tanks 31 and 32 are placed in communication with each other through a water transverse channel 33 of sufficiently large cross-sectional area and with the outside atmosphere through connecting branches 42 and 43. These branches may be closed by shut-off devices; for instance flaps 44 and 45. Both flaps may be held in the open position by means of electromagnets 46 and 47. The circuit of the electromagnets extends through a hand-operated switch 48 and a contact device which consists of a contact segment 49 fixed relatively to the ship and of a contact arm 50 secured to the axis of a rolling angle responsive instrument 51. The latter may as usual be designed in the form of a gyroscope. The contact segment 49 has such a width that upon attaining a predetermined list of the ship, the contact arm 50 moves away from the contact segment 49 thus deenergizing the magnets 46 and 47. In this case, the flaps 44 and 45 close and the metacentric height of the ship is, therefore, increased, automatically. Also by the hand-operated switch 48, the magnets 46 and 47 may be deenergized and, therefore, the installation may be shut down. As long as the magnets 46 and 47 are deenergized, the tank liquid forms a portion of the ship body upon which depends the metacentric height of the ship.

It is understood that the flaps 44 and 45 may be replaced by other shut-off devices and, under circumstances, may be combined to form a single shut-off member arranged in the air transverse channel or in the water transverse channel.

For the purposes of the invention, for instance, fuel tanks may, of course, be employed as already above mentioned. When fuel is delivered from the fuel tank the mean liquid level lowers. For this reason, the connecting branches 52 and 53 through which both tanks 31 and 32 communicate with the outside atmosphere are each provided as shown in Fig. 7 with a telescopically designed part 54 and 55 respectively. With the aid of a rack and pinion gear 56 and 57 respectively, the parts 54 and 55 may be always adjusted to the desired distance from the liquid level. In this manner, it is easily possible to so adjust the tubular portion 54 and 55 according to the scales allotted to the gears 56 and 57 and to the indications of a liquid gauge indicating the liquid level in the tanks 31 and 32 that upon the attainment of a given list of the ship the liquid at the inclined side of the tank enters the conduit 54 or 55. If desired, the conduits 54 and 55 could be provided with floats as shown in Fig. 5. 58 and 59 are, for instance, hand-operated shut-off devices arranged in the branches 52 and 53.

In Fig. 7 it is assumed that the gears 56 and 57 are actuated by means of a crank. Of course, it is also possible to provide an automatic adjusting device which is controlled in accordance with a water gauge.

In the embodiments shown in Figs. 1 to 7 so called high tanks are employed. Also by the use of flat tanks as shown in Figs. 8 and 9 the invention may be carried into practice. The cover of the tank 60 consists of two plane halves 61 and 62 inclined towards the center line of the ship. They are so inclined to the horizontal that the tank liquid at a certain list of the ship of, for instance, 4° comes into contact with either cover half 61 or 62. The tank 60 is preferably filled up to such an extent that the liquid level comes into contact with the line of intersection of the two cover halves 61 and 62 as shown in Fig. 8.

According to the above considerations the embodiment shown in Figs. 8 and 9 operate as follows: As long as the angle of list of the ship does not exceed a given value, the tank 60 forms a "free surface." This property is lost in part if the list of the ship exceeds the above-mentioned angle. The portion of the tank liquid in the one half then forms a portion of the ship body with the result that this portion of the tank liquid contributes to increase the metacentric height of the ship.

63 and 64 are branches through which the air spaces of two tank halves are in communication with the outside atmosphere.

It is advisable to build in web plates 65 in order to damp to a certain extent the water motion if the ship is inclined at either side. The air may escape from the single chambers formed of the plates 65 through openings 66.

The tanks according to the invention could be provided with a constant amount of liquid. However, in this case it would not be easily possible to put the tanks at will into and out of operation; that is to say to vary the metacentric height of the ship with the aid of the tank arrangement without list of the ship. This may be accomplished by providing means for varying the contents of the tank. It is evident that when the tank is completely charged with liquid, the tank arrangement is always shut down so that the contents of the tank is to be added to the ship body determining the metacentric height of the ship.

In the embodiment shown in Figs. 8 and 9 besides the tank 60 a storage tank 67 is provided for the above-mentioned purpose. The storage tank 67 has preferably such a capacity that the liquid contained therein suffices to fill up the residual space of the tank 60, i. e., the space which remains free when filling up the tank 60 according to Fig. 8. By means of a pump 69 driven by a motor 68 and of the conduit 70, the liquid of the tank 67 may be forced into the tank 60. In the partition wall 71 between both tanks 60 and 67 is arranged a hand-operated shut-off device 72. Upon opening the latter, a portion of the tank liquid flows from the tank 60 back into the tank 67.

Measuring devices are preferably provided for indicating the corresponding contents of the tank 60. 73 and 74 are branches for placing the tanks in communication with the outside atmosphere.

Instead of making the chamber cover 61, 62 of two planes it might also be uniformly curved so that with increasing list of the ship, the metacentric height of the ship increases and vice versa. According to the invention the double bottom of the ship may be employed as a tank by arranging the openings provided within the tank space in the keel and in the longitudinal girders in such a manner that the lines passing through the apexes of these openings are inclined to the horizontal in accordance with the angle of inclination of the ship at which the tank arrangement should automatically increase the metacentric height of the ship.

By the use of the double bottom as a tank, a considerable saving in space is obtained. By arranging the openings in the keel and in the longitudinal girders in such a manner that the apexes of these openings lie on a straight line inclined at a given angle to the horizontal, the advantage is obtained in that by the use of the simplest means the metacentric height increases automatically upon exceeding a predetermined angle of inclination.

Fig. 10 shows a transverse section of such an embodiment.

As will be seen from Fig. 10, the central portion of the keel 75 and the central portion of the other longitudinal girders 76 are provided with openings 77 and 78 so that the single chambers form between these parts are in communication with one another through said openings. The individual openings are so disposed that the lines 79 and 80 drawn through the apexes of the openings are inclined at a certain angle β, preferably at an angle of 3° to 4°, to the horizontal. 81 and 82 are conduit branches through which the air space of the tank arrangement is in communication with the outside atmosphere. With a normal charge of liquid, the level of the tank liquid when the ship is in a horizontal position passes approximately through the apex of the opening 77. Consequently, the arrangement operates as follows:

As long as the angle of inclination of the ship is smaller than the above-mentioned angle β, the tank liquid forms a "free surface" and reduces the metacentric height, i. e., the stability of the ship. If the angle of inclination of the ship attains the value β, the tank liquid interrupts the free air connection between the single chambers of the double bottom with the result that the tank liquid must partake in the motion of the ship brought about by an increase of the list of the ship beyond the anglar value β. This means, however, that in this state the tank liquid at the inclined ship side and substantially also the liquid at the other side of the ship form so to say a portion of the ship body and, consequently, the metacentric height of the ship increases rapidly with an increasing list of the ship. That is to say if the angle of inclination of the ship exceeds the value β, the metacentric height of the ship increases automatically, whereas if the list of the ship decreases below the value β, the metacentric height of the ship attains its minimum value.

In the preferred embodiment sea-water is employed as tank liquid and, to this end, the tank is connected with the sea through a conduit 83. In the conduit 83 is arranged a propeller 84 which is operatively connected with a motor 85 as well as a shut-off device 86. To fill up the tank, the shut-off device need only be opened. The sea-water then flows by itself into the tank. The tank is normally charged with liquid up to the level shown in Fig. 10. When the liquid attains this level, the shut-off device 86 must be closed.

If the tank arrangement is to be put out of operation, this may be effected in a simple manner by charging the tanks with liquid beyond the normal filling by opening the shut-off device 86 until at all points the tank contents forms so to say a portion of the ship body so that there is no longer a "free surface". Consequently, when the tank arrangement is put out of operation, the metacentric height of the ship increases up to an extent depending upon the construction of the chambers. If the tank arrangement is to be put again into operation, the excess charge of the tank is pumped back into the sea with the aid of the propeller 84. To prevent the tank from being completely emptied which might lead to a disturbing instability of the ship, it is advisable that the end of the conduit 83 within the tank contacts with the normal liquid level as shown.

Instead of the connection with the sea as shown in Fig. 10, various tanks might be formed within the double bottom as will be seen from Figs. 8 and 9, one of which serves for the above mentioned purposes, whereas the other only for the reception of that amount of liquid which is necessary to shut down the tank arrangement. This may be accomplished in the manner as above described. Furthermore, by the use of the double bottom differently long tanks may be provided lying in series in the direction of the longitudinal axis of the ship in order to gradually reduce, as the case may be, the metacentric height of the ship.

HERMANN HORT.