A ship stabilising apparatus comprising means to stabilise a ship by the tilting of fins extended therefrom, said fins being operable to apply anti-rolling forces, anti-pitching forces or forces which are an integration of anti-rolling forces and anti-pitching forces, said forces being modulated to suit the ship's immediate stabilising requirements and said tilting to be timed to avoid the application of pro-oscillatory forces to the ship and said fins in special circumstances being controllable to apply continuously to the ship about its rolling axis a clockwise or an anti-clockwise torque.

18 Claims, 20 Drawing Figures
STABILISING APPARATUS FOR SHIPS AND THE LIKE

BACKGROUND OF THE INVENTION

The invention relates to means whereby rolling and pitching, being oscillatory motions of a ship, are to be minimised; and also means to apply to the ship torsional couples which will oppose the ship's tendency to swing outwards whilst turning.

Rolling occurs about a rolling axis which lies in a fore-and-aft direction in a ship and is a motion in which momentum accumulates from consecutive waves, causing the ship to overtravel such effects as can be produced by individual waves, and inertial members as hereinafter described which roll or pitch in concert with the ship will tend to overtravel for the same reason. Pitching is similar to rolling in that great momentum accumulates, but differs in that independently of rolling, it acts about a pitching axis which lies across the ship.

To neutralise the said great momenta in a very brief time by the transference of great volumes of water ballast is not practicable; the sudden movements of heavy weights is too cumbersome and dangerous; and only fine which, controlled and motivated by entirely mechanical means, reverse their anti-oscillatory efforts very quickly, thereby deflecting great quantities of the ambient water upward or downward are herein regarded as acceptable. When a fin's leading edge is raised the said water applies a lifting force to that fin and that fin's setting is referred to as positive tilt; and the force which causes or tends to cause that setting is hereinafter referred to as a positive effort. To enable a fin to oppose an oscillatory motion of the ship substantially during the entire period of each oscillation the application of an anti-oscillatory effort must commence before the previous oscillation ends, and must be half completed at the instant when that oscillation ends. This timing obviates the production by the respective fin of pro-oscillatory efforts which would detract from the efficiency of the apparatus and cause much power-wasting turbulence.

Whilst a ship is moving slowly over critically shallow water it must have fins of sufficient area and angle of tilt to achieve stabilisation, but such fins or such setting might be excessive for application when the ship is moving at its usual speed in the open sea.

To obtain the best locations for fins the following facts require consideration. Fins, if extended from near the bows can be operated to reduce rolling or pitching or both, and might be essential to a very large ship although they are prone to damage; if extended from amidships they can be operated only to reduce rolling, but if extended from near the stern they can be operated to reduce both rolling and pitching, are reasonably safe from damage, and need not add greatly to the turbulence inevitably caused by the rudder and propellers.

In conventional fin design there are some objectionable features. As a first instance a fin is often supported by a single shaft and has a considerable extended length which creates a great bending moment, necessitating a large supporting shaft which, in combination with the fin having a moderate fore-and-aft dimension and usually a tilted trailing flap also, requires a fin having a section which is inevitably very inefficient in a hydrodynamical sense, which causes a heavy drag even when untilted, and which cannot produce an appreciable stabilising force until a high ship's speed and angle of tilt have been applied, and such a fin in all circumstances of operation will cause inordinate drag and turbulence. As a second instance, to reduce pitching, many modern ships are built with a bulbous bow to reduce pitching thereby losing at all times and speeds much of the benefit they should have received from pure streamlining.

It is an object of the present invention to provide a ship stabilising apparatus which overcomes the above-described disadvantages of the prior art and provides for more effective stabilisation of a ship during all speed conditions and angles of tilt of the fin or fins.

Other objects of the invention are:

(a) to apply to the fin or fins both anti-rolling and anti-pitching efforts in an integrated form that will cause minimal turbulence; (b) to apply the said efforts at the commencement of an anticipatory period, such period being the time required by the fin operating mechanism to half complete its effort-reversing action, by which timing the current anti-oscillatory effort will cease when the current oscillation ceases, thus obviating the possibility of a pro-oscillatory effort being applied to said fin whereby much power wasting turbulence would be caused; and (c) to provide a fin having a minimal bending moment at its points of support.

According to the invention there is provided a ship stabilising apparatus comprising at least one fin, an oscillating sensor, a reactor controlled by said sensor, and a fin operating mechanism operably connected between said reactor and said fin, said sensor including an inertial member mounted so as to oscillate responsive to oscillations of the ship, said inertial member being operable to control a supply of motive liquid to potential controlling means of said reactor and a supply of motive liquid to motive means of said reactor for movement of an actuating means therein, said potential controlling means being adapted to regulate the amount of movement of said actuating means and said actuating means being adapted to transmit anti-oscillatory efforts to the fin operating mechanism.

The apparatus of the invention may also include a further similarly operable sensor and similarly operable reactor, one sensor and reactor being responsive to rolling oscillations and the other sensor and reactor being responsive to pitching oscillations, both reactors being operable to transmit their respective efforts to said fin operating mechanism for integration thereby into one stabilising effort.

The fin or fins may be of longer dimension along the ship and where two fins are used, one on either side of the ship, each fin is operatively connected to a fin operating mechanism, each fin operating mechanism being connected to both reactors.

The novel features which are considered as characteristic of the invention are set forth in particular in the appended claims, and in order that the invention and its manner of performance will be more fully described reference will now be made to embodiments of the invention as illustrated in the accompanying drawings.

FIGS. 1A and 1B are a flow diagram showing the application of stabilising efforts to a ship whilst oscillating at a time before mid-roll and mid-pitch;

FIG. 2 is a part-sectional elevation through a roll sensor of the invention, taken along line 2--2 of FIG. 4;

FIG. 3 is a part-sectional elevation through the roll sensor taken along line 3--3 of FIG. 2;
FIG. 4 is a fragmentary section through the inertial member of the sensor taken along the line 4—4 of FIG. 2.

FIG. 5 is a fragmentary section of a rotary valve taken along the lines 5—5 of FIG. 3;

FIG. 6 is a similar section to FIG. 5 taken along the line 6—6 of FIG. 3;

FIG. 7 is a fragmentary section in plan taken along the line 7—7 of FIG. 3;

FIG. 8 is a part-sectional plan of a reactor of the invention along the line 8—8 of FIG. 9;

FIG. 9 is a sectional elevation taken along the line 9—9 of FIG. 8;

FIG. 10 is a sectional elevation of a fin and its operating mechanism taken along the line 10—10 of FIG. 13;

FIGS. 11A, 11B and 11C illustrate the outlines of ships fitted with stabilising fins;

FIG. 12 is a sectional elevation taken along the line 12—12 of FIG. 9;

FIG. 13 is a part-sectional view taken along the line 13—13 of FIG. 10;

FIG. 14 is a sectional view taken along the line 14—14 of FIG. 13;

FIG. 15 is a sectional view taken along the line 15—15 of FIG. 13;

FIG. 16 is a sectional view of a first modified form of reactor; and

FIG. 17 is a sectional view of a second modified form of reactor.

DESCRIPTION OF THE PREFERRED EMBODIMENT

To find the most suitable positions at which to install fins on a ship FIGS. 11A, 11B and 11C show the outlines of ships which are rolling to starboard whilst their sterns are rising. Ships 1 and 6 have anti-rolling fins 2, 3, 7 and 8 of conventional outline, and similar anti-pitching fins 4, 5, 9 and 10; and necessarily the fins 3 and 8 would be positively tilted, whilst the remaining fins would be negatively tilted, and so both ships 1 and 6 would have on their starboard side two oppositely tilted fins thereby causing much turbulence and wastage of power. However, by integrating the efforts as applied to the fins 8 and 10 and applying the resultant tilt to a single fin such as fin 10, that fin's tilt would approximate to zero and the wastage of power thereat would be obviated; and by similarly integrating the efforts as applied to the fins 7 and 9 and applying the resultant tilt to a single fin such as fin 9, that fin would apply negative tilt to the full extent required to oppose both rolling and pitching at that position at that time.

FIG. 11C shows the location of fins in the preferred arrangement wherein a ship 11 has a port fin 12 with a leading edge 12A, a sea-chest 14, and a starboard fin 13 with a leading edge 13A and a sea-chest 15. The preferred fins 12 and 13 are substantially planar in form and rectangular in outline, or may be curved to conform to the surface of the ship, and their sea-chests 14 and 15 are flush or streamlined with the surface of the ship.

The preferred apparatus for controlling both roll and pitch of a ship consists of six pipe connected mechanisms; a roll sensor and a pitch sensor each having and controlling a reactor; a port and a starboard fin each having means to receive and apply anti-rolling or anti-pitching efforts to tilt the fin suitably, and means to receive both types of effort simultaneously, to integrate them, and so to tilt the fin.

The roll sensor, (FIGS. 2 and 3) has an inertial member 16 consisting of an air-filled annulus which has an attached weight 16A, and is mounted on two identical arms 17, (FIG. 4), which are mounted on a central member 18 fixedly mounted on a driving shaft 19 which is rotatably mounted in a liquid filled casing 20 in which the inertial member 16 being, with the associated members of suitable configuration, has zero buoyancy. The driving shaft 19 is located in parallel relationship with, and preferably close to the ship's rolling axis, allowing the inertial member 16 with minimal friction to roll in concert with the rolling of the ship. The member 16 being gimbal mounted as explained, can also oscillate as shown in FIG. 2 about the arms 17 in response to the ship's pitching, such action being resisted by two side rods 21 which are pivotally mounted as shown in FIG. 2, and which mount springs 22 which return the member 16 to its normal position after pitching.

Drive from the shaft 19 passes to a sprocket wheel 23, a driving chain 24, a sprocket wheel 25, a counter-shaft 26, and gear wheels 27 and 28 to rotate a sleeve 29 which is internally splined and houses a splined spindle 30. Light flyballs 31, (FIG. 2), are linked to the sleeve 29 and to a collar 32 mounted on the spindle 30. As shown in FIG. 2 the ship's rolling has caused the flyballs 31 to rotate and swing outward thereby lowering the spindle 30 against pressure exerted by a spring 33. The spindle has a first annular passage 30A and a second annular passage 30B, (FIG. 3), and passes through a housing 34 mounted on the casing 20. The housing has two passages 34C and 34D in opposite relationship, and also has two passages 34B and 34A which are also in opposite relationship. The passage 30B is located on a plane above the passages 34C and 34D whilst the flyballs 31 are inactive, but when they rotate the passage 30B lowers and allows motive liquid to flow through the passages 34C, 30B and 34D to the roll reactor (FIGS. 3 and 8), the rate of flow being modulated by the passage 30B which, being of varying depth as shown, allows an increasing rate of flow when the angulur velocity of rolling increases, thereby passing to the reactor a volume of fluid proportional to the stabilising effort such as is instantaneously required.

Mounted on the shaft 19 a brake drum 35 (FIGS. 3 and 7) has a geared section 35A by which drive passes to a step-up gear 36 mounted on a first rotary valve 37, (FIG. 3), which has two identical arcuate passages 37A and 37B, (FIGS. 1B, 5 and 6) and is mounted in a housing 39, said housing having two passages 38A and 38B connected respectively to pipes 127 and 129, (FIG. 1B). As shown in FIG. 3 a brake band 39, pivotally mounted at one end on a boss 40, has at its other end an oval hole 39A through which the spindle 30 passes. When the flyballs 31 are idle a collar 41 holds the band 39 free of the drum 35, but when the flyballs 31 rotate the spindle 30 descends and a collar 42 mounted thereon compresses a weak spring 43 whereby the brake band 39 applies to the brake drum 35 sufficient braking effect to obviate overtravel of the inertial member 16 and so bring it to rest at the instant when the current roll ends.

The roll reactor, (FIGS. 8, 9 and 12), has a body 44 which is spaced by rods 45 from a motive cylinder 46 having a piston 47 with an extended piston rod 48 which mounts a cruciform crosshead 49 and is housed
in the body 44. Two biasing springs 48A and 48B mounted on the piston rod 48 abut the cross head 49 and respectively the motive cylinder 46 and the body 44, and said springs, acting through the crosshead 49 and the piston rod 48, centralize the piston 47 in the cylinder 46". In the body 44, a first potential-controlling cylinder 44A has a piston 50 which is contacted by a buffer spring 51 and is attached to an extended piston rod 52 which has an annular passage 52A thereon and is associated with a housing 46A, a channel 46B, a passage 46C, a collar 53, a plurality of slots 46D in the cylinder 46 and a cylinder cover 44B. A second potential-controlling cylinder 44C is similar to the said first cylinder 44A having a piston, a piston rod 54 having an annular passage 54A and is associated with a passage 46E, a plurality of slots 46F in the cylinder 46, and a buffer spring 55. Both rods 52 and 54 are linked to an equalising lever 56 by links 57, and movement of the rods 52 and 54 is limited by the collar 53 engaging an abutment 53A and piston 50 engaging against the inner face of the cylinder cover 44B.

Whilst the roll reactor is operating normally a control valve 67, (FIG. 8), remains closed and the modulated liquid supply received from the passage 34D, (FIG. 3), passes through a pipe 66, a control valve 68, (FIG. 8), passages 44D and 44E into the potential-controlling cylinders 44A and 44C, and to one or more regulating valves such as 69 or 71 which are manually set to discharge the liquid at a steady rate whilst maintaining in the said cylinders 44A and 44C pressures which, balanced by the pressures exerted by the buffer springs 51 and 55, maintain suitable adjustment of the locations of the passages 52A and 54A to imprison at each end of each stroke a suitable volume of liquid in the cylinder 46 whereby the length of stroke of the piston 47 is controlled. Valves such as 69 and 71 can be located at any near or remote pipe-connected station and adjustments of their setting provides an overriding adjustment of the said potential-controlling action customarily provided by the passage 30B (FIGS. 2 and 3).

When motive liquid is supplied through the pipe 66, an over-riding adjustment of the supply can be effected by supplying additional motive liquid through and by the control valve 67 which can be located at any near or remote pipe-connected station. In the event of malfunction of the supply delivered through pipe 66, the valve 68 (FIG. 8) should be closed and the requisite liquid pressure can then be maintained in the cylinders 44A and 44C by motive liquid received through and by manual adjustment of the valve 67.

The body 44 also has a first master cylinder 44F, (FIG. 9), with a piston and piston rod which is attached to the cross-head 49, and also has two passages 44G and 44H through which, by means of two hydraulic circuits, anti-roll efforts are delivered as will be explained. These efforts are proportional to the stroke of the piston 47, to the volume of fluid delivered by the cylinder 44F; and to the ship's anti-roll efforts as then required for the starboard fin 13, (FIG. 1B). Similarly a second master cylinder 44J, having a piston, a piston rod, and passage 44K and 44L, delivers anti-roll efforts to the port fin 12, (FIG. 1A).

The fin operating mechanism, (FIGS. 10, 13 and 15), of the starboard fin 13 has an anti-rolling slave cylinder 72, (FIG. 15), having a piston 73 connected by a piston rod 74 to a crosshead 75 to which are also attached two rack-gearered bars 76 which are slidably housed in the body of the cylinder 72 (FIG. 13). Also shown in FIG. 15 is an anti-pitching slave cylinder 77 which is operationally identical with the cylinder 72, having a piston, a piston rod, a crosshead, and two rack-gearered bars 78. Between the bodies of the cylinders 72 and 77 a movable member 79 is located, having a housing 81 in which a shaft 82 can rotate, (FIGS. 10 and 15). On each end of the shaft 82 is fixedly mounted a gear 83, which meshes with the rack-gearered bars 76 and 78, (FIG. 15), of which the bars 76 by their axial position as in FIGS. 1A and 1B indicate the potential of the anti-rolling effort being then applied, and the bars 78 indicate the potential of the anti-pitching effort, so that the position of the shaft 82 and the movable member 79 indicate the integration of both efforts.

The sea-chest 15 has a body 15A, (FIG. 14), is integral with the hull of the ship 11 and has an outer cover 15B which has an opening 15C, (FIG. 13), and a split bearing 15D, (FIGS. 10 and 14), and also has an inner face plate 15E which is strengthened by a number of ribs 15F which are not part of the invention, but are shown dotted in FIG. 14. Each of two links 84, (FIG. 13), connects the movable member 79 to a lever 85 mounted on a shaft 86 which is rotatably mounted in the inner face plate 15E and the outer cover 15B of the sea chest, (FIG. 14). On each shaft 86 is mounted a geared sector 87 which meshes with a geared sector 88A of a fin carrier 88 which has a slot 88B, (FIG. 14), on its sea-ward face to receive the fin 13, and also has a plurality of smooth surfaced housings such as 88C and 88D and one housing 88E to receive a pivot shaft 13D of the fin 13. The fin (FIG. 14), has a leading edge 13A, two tongues 13B, two stems 13C which have square threads, and the pivot shaft 13D which fits rotatably, (a) in the split bearing 15D, (b) in the housing 88E of the fin carrier, and (c) in a gear equipped bush 89 which has a register 89A and is housed in the cover 15E. From a reversible motor 91, (FIG. 10), drive passes by a chain 92 to a sprocket wheel 93 mounted on the bush 89 and thence to two gears 94 and 95 (FIG. 14), having registers 94A and 95A and internal square threads to receive the stems 13C so that the gears 94, 94 and 95, when rotated by the motor 91, extend the fin from its housings through the opening 15C into the ambient water, or retract it completely within the outline of the ship whereby the tongues 13B and the stems 13C retract into watertight caps or covers 96 and 97. The outline of the opening 15C, (FIG. 13), is such that the fin can be tilted whilst retracted, or partly or fully extended, by which action the optimum combination of extension and tilt can be applied to satisfy the ship's immediate stabilising requirements.

As an alternative form of the tongues 13B and their caps 96 may be omitted.

FIGS. 1A and 1B show the application of stabilising forces as applied to the ship 11 whilst it is rolling to starboard and the stern is rising, at a time shortly before mid-roll and mid-pitch. Motive fluid has passed from the pipe 132, through the passages 37A, 38A, a pipe 127, (with pipes 128 through 133 is shown on FIG. 1B), a transverse passage 98A, (which with a similar passage 98B is located in a plunger 98 which is housed in an tilt-fixing cylinder 99), and thence through a port 100A into a first reactor controlling cylinder, (which also has a second port 100B), whereas it has moved to the right a hollow piston 101, a piston rod 102, and a piston valve 106 in a second reactor control-
ling cylinder 107 (FIG. 1A), the hollow piston 101 slidably housing a piston rod 102, which, having a fixed flange 103 thereon is positioned in the hollow piston 101 by two buffer springs 104 and 105; the piston rod 102 being attached to the piston valve 106, (FIG. 1A), which has two transverse passages 106A and 106B, the passage 106A being so located that motive liquid has passed through cylinder 108, and the passage 106A, into the motive cylinder 46 of the roll reactor and has raised the piston 47 therein and the pistons in the master cylinders 44F and 44J, thereby causing each said master cylinder to deliver an anti-roll effort whilst spent liquid has left the cylinder 46 through a passage 106B. The piston valve 106 is housed in a second reactor controlling cylinder 107 having ten passages as in FIG. 1A.

As an alternative to the hollow piston 101 a piston of conventional construction fixedly mounted on a piston rod may be substituted.

The pitch sensor oscillates about the pitching axis which lies across the ship and with the pitch reactor is not shown. The motion of pitching being relatively small in an angular sense a much larger inertial member and a great or greater step-up gear is necessary to rotate flyballs such as 31 and a first rotary valve such as 37 with its associated components as in FIGS. 2 and 3 to control and regulate the effort-potential of the pitch reactor; and it is necessary only to show on FIG. 1B that a motive cylinder 109 of the pitch reactor, activated by a pitch sensor, has caused two master cylinders 111A and 111B to deliver anti-pitching efforts to two slave cylinders 77 and 116. Delivery of liquid from the master cylinder 111A has passed through a valve 115 (FIG. 1B), which, in conjunction with valves 112, 113 and 114, is gang-controlled for a purpose which will be explained.

FIGS. 1A and 1B show the piping means whereby the four master cylinders deliver efforts each to a respective slave cylinder as follows; 44F to 72, a positive effort, and an opposite manner of application 44J to 117, a negative effort; 111A to 77 and 111B to 116 in a parallel manner of application, both being negative efforts. It is seen that the former two efforts are applied to the starboard fin 13 and that they approximately neutralise one another whereby allowing the fin to occupy its normal position, whilst the latter two efforts being both negative apply to the port fin 12 a degree of tilt according to a summation of both efforts. Thus it is seen that the four said stabilising efforts as applied to the fins 12 and 13 have caused the fins to be set as the ship 11 in the said circumstances required.

In the preferred embodiment, the fins, being responsive both to a roll reactor and a pitch reactor, can also respond to either reactor separately if and when the other reactor is suitably immobilised, which immobilisation can be effected by a clutching means which holds in their mid-stroke position the piston in the slave cylinders which are controlled by the said immobilised reactor. The throttle valve 110, (FIG. 1A), can be adjusted and closed to apply the required clutching means to the pistons in the said slave cylinders.

At the commencement of the next roll the first rotary valve 37 commences to rotate anti-clockwise and after mid-roll it will allow motive liquid to pass through the passage 37B, the pipe 129, the passages 98B and 100B into the right hand end of the first reactor-controlling cylinder 100 wherein it will move the hollow piston 101 toward the left end of the said cylinder whilst spent liquid will leave the cylinder through the passage 98A, the pipe 127 and the passage 37A. The said movement of the piston 103 will compress the spring 105 against the fixed flange 103 and will cause the piston rod 102 and the piston valve 106 (FIG. 1A) to move slightly to the left thereby checking the delivery of motive liquid to, and the discharge of spent liquid from, the motive cylinder 46 of the roll reactor. At the same time the movement of the piston valve 106 will compress air (or other suitable gas) in the left and empty of the cylinder 107 and its associated piping, the air passing through a check valve 120 and a second air controlling valve 123 and being retained by two check valves 118 and 119, by a first air control valve 121, and by the spindle 30 being in a lowered position whilst the flyballs 31 are rotating as on FIG. 4. Whilst the piston valve 106 moves to the left, air passes into the cylinder 107 through a check valve 122. These conditions will be maintained until the rolling velocity of the ship diminishes, whereby the spindle 30 will rise until, at the commencement of an anticipatory period, the passage 30A will connect the passages 30B and 34A thereby releasing the compressed air and tripping the action of the roll reactor. When the compressed air has been released as explained the piston valve 106 will move to the left hand end of the cylinder 107 and thereby release the pressure in the motive cylinder 46 (see FIG. 1A), thereby enabling a biasing spring 48A or 48B (see FIGS. 8 and 9) to move the piston 46 whereupon the biasing spring and motive liquid which enters the motive cylinder 46 through the slots 46D or 46F move the piston 46 to its next position thereby compressing a respective biasing spring 48B or 48A and reversing the positions of the pistons in the cylinders, 46, 44F and 44J, thereby reversing the efforts that had been applied to the pistons in the slave cylinders 72 and 117. At the same time spent liquid will leave the cylinder 46 through the passage 106A. Anti-pitch efforts will be reversed in identical manner.

In the event of (a) malfunction of the said means whereby the air is released; or (b), a high degree of stabilisation being required, it will be necessary that the second air controlling valve 123, (FIG. 1A), be closed, and that the first air controlling valve 121, (which can be located at any near or remote pipe-connected station), be manually operated to trip the respective reactor.

To oppose the ship's tendency to swing outwards whilst turning it is necessary to set the fins to apply a suitable counter-torque by utilising the tilt-fixing cylinder 99 (FIG. 1B) and a second rotary valve 125 which has a hand lever 125A, two arcuate passages on different planes, and in its body six pipe connections as shown in FIG. 1B. The tilt-fixing cylinder 99 has a long key-way 99A, eight pipe connections or passages, and mounts a retractable boss 124. In the effort fixing cylinder 99 the plunger 98 has the said passages 98A and 98B, two trough-like passages 98C and 98D, a housing 98G for the retractable boss 124, and a fixed key 98H which slides in the key-way 99A. The pitch sensor is similarly equipped, having a first and a second reactor-controlling cylinder such as 100, and 107, a tilt fixing cylinder such as 99 and associated components; and is activated by motive liquid passing to and from its tilt fixing cylinder through the pipes 131 and 133.
To produce a counter-torque to oppose a ship's tendency to swing to starboard it is necessary:

(a) from tilt-fixing cylinders such as 99 to retract the bosses such as 124;
(b) to reverse gang-controlled valves 112, 113, 114 and 115 shown in FIG. 1B, by which operation all positive efforts delivered by the master cylinder 111A will be converted from positive to negative and the reverse; and
(c) to rotate a second rotary valve 125 clockwise thereby allowing motive liquid from an external source to pass through the said rotary valve and through the pipe 128 into the tilt fixing cylinder 99 thereby causing the plunger 98 to move to the right hand end of the cylinder 99 thereby displacing the passages 98A and 98B and invalidating the first rotary valve 37 and allowing motive liquid to pass from the cylinder 99 through the passage 98C and the port 100A into the cylinder 100 wherein it will hold the piston 101 in the position shown in FIG. 1B and thereby cause the piston in the slave cylinder 117 to apply a first negative effort to the port fin 12 whilst the piston in the slave cylinder 72 will apply a first positive effort to the starboard fin 13, both efforts being as shown in FIGS. 1A and 1B. At the same time motive liquid released by the second rotary valve 125 will pass through the pipe 131 to activate in identical manner in the pitch sensor a plunger such as 98 whereby the associated components of the pitch sensor will cause the pistons in the cylinders 109, 111A and 111B to be held in their raised positions as shown in FIG. 1B and the piston in the slave cylinder 116 will thereby apply a second negative effort to the port fin 12. At the same time the ganged valves 112 through 115 being reversed allow motive liquid from the cylinder 111A to pass through the valve 114 and cause the piston in the slave cylinder 77 to apply a second positive effort to the starboard fin 13. Thus it is seen that both fins would be set to oppose the ship's tendency to swing to starboard. To oppose the ship's tendency to swing to port the same procedure is to be followed except that the second rotary valve 125 is to be rotated anti-clockwise.

A first alternative reactor whose central plane is shown in sectional plan on FIG. 16 has a stroke-adjustment means identical with that shown on FIG. 8, and has slots 138 which are similar to the slots 46D as shown on FIG. 8 but are forked to direct the flow of motive liquid to twin motive cylinders 139 and 141, whereby a cylinder 144 activates a master cylinder 143 as shown, and the cylinder 139 activates a master cylinder 142, (the latter two cylinders not being shown), and thus each master cylinder delivers an anti-oscillatory effort as in the preferred embodiment.

A second alternative reactor shown in sectional plan on FIG. 17 has a motive cylinder 144 having stroke adjustment means identical with that in the preferred embodiment, but differs therefrom in having two extended piston rods which activate in tandem relationship two master cylinders 145 and 146 thereby delivering anti-oscillatory efforts as in the preferred embodiment.

Pressurized motive liquid is used to control and activate the preferred apparatus because it gives a positive and very rapid response and because it enables constant automatic stroke adjustment to be applied to a piston which reciprocates in a motive cylinder.

It is to be understood that the invention is not limited to the matter disclosed but includes all such variations and modifications of the means described which shall fall within the spirit of the invention and the scope of the appended claims; for example (a) an air-surrounded inertial member fixedly or gimbal mounted on a shaft located in parallel relationship to the axis of oscillation as described, or (b) a gyroscope with precessional control may be substituted for the embodiment of the inertial member as hereinafter described.

I claim:

1. In a ship stabilizing apparatus comprising a tiltable fin, an oscillatory sensor, a reactor mechanism controlled by said sensor and fin operating mechanism operably connected between said reactor mechanism and said fin; said sensor including an inertial member mounted so as to oscillate responsive to oscillations of the ship, inertial means to which the inertial member is drive connected, first and second valvular means drive connected to the inertial means, potential controlling means of said reactor mechanism to which a modulated supply of motive liquid is provided by operation of said first valvular means, a motive cylinder of said reactor mechanism to which motive liquid is supplied, piston valve means to control the supply of motive liquid to the said motive cylinder, an actuating piston in the said motive cylinder moved by the motive liquid whereby anti-oscillatory efforts are applied to the fin operating mechanism, said potential controlling means being adapted to regulate the amount of movement of the said actuating piston in accordance with the ship's angular displacement and angular velocity of oscillation, said fin operating mechanism including drive means connected between said actuating piston and the fin and operable on movement of the actuating piston to transmit tilting movement to the fin.

2. The combination of claim 1 wherein braking means are provided on the drive from the inertial member so as to apply a braking effect on said inertial member at all but low angular velocities of oscillation, said braking effect being substantially proportional to said angular velocities and being adjusted to cause the oscillatory periods of the inertial member and of the ship to end coincidentally, whereby the action of the reactor will be regulated for correctly timing the reversal of the tilting of a fin.

3. The combination of claim 1 wherein manually operable valvular means are provided to supply motive liquid to said potential controlling means either as an alternative source to the modulated supply or to augment said modulated supply.

4. The combination of claim 1, including two piston rods attached to the said actuating piston, two master cylinders located in tandem relationship with said motive cylinder, and a piston in each of the two master cylinders connected with said piston in said motive cylinder by said piston rods.

5. A ship stabilizing apparatus according to claim 1, including two master cylinders for producing anti-oscillatory efforts a motive cylinder for activating each said master cylinder, a potential-controlling valvular means for regulating said motive cylinder to transmit anti-oscillatory efforts to a respective fin operating mechanism.

6. The combination of claim 1, wherein said potential controlling means comprises at least one cylinder, a spring biased piston housed in said cylinder, a pair of piston valves operably connected to said spring biased piston and associated with said motive cylinder so as to
I regulate the retention of liquid in either end of the cylinder and thereby control the length of stroke of the actuating piston whereby the potential of anti-oscillatory efforts transmitted to the fin operating mechanism is proportional to the immediate anti-oscillatory requirements of the ship.

7. In a ship stabilizing apparatus comprising a tiltable fin, an oscillatory sensor, a reactor mechanism controlled by the said sensor, and a fin operating mechanism operably connected between said reactor mechanism and said fin; said sensor including an inertial member mounted so as to oscillate responsive to oscillations of the ship, inertial means to which the inertial member is drive connected, valvular means drive connected to the inertial means, a piston activated through the said inertial means, a piston valve on said piston operable to control the supply of motive liquid, a motive cylinder of said reactor mechanism to which the motive liquid is supplied, an actuating piston in the said motive cylinder moved by the motive liquid whereby anti-oscillatory efforts are applied to the said fin operating mechanism, which includes drive means connected between said actuating piston and the fin and operable on movement of the actuating piston to transmit tilting movement to the fin.

8. A ship stabilizing apparatus according to claim 1, including a first reactor controlling cylinder connected to the second valvular means, a piston housed in the first reactor controlling cylinder, a piston rod on which the piston is mounted, a second reactor controlling cylinder, a piston valve means in the said second reactor controlling cylinder and connected to the piston rod which is subject at either end thereof to gas pressure so as to arrest the movement of said piston valve until gas exhaust valve means automatically operable by said inertial member when the angular velocity of the ship's oscillation approaches a zero value exhausts gas from one end of said piston valve and allows the piston valve to complete its movement to reverse the supply of motive liquid to the motive cylinder of the reactor and thereby reverse the anti-oscillatory effort applied to the fin operating mechanism at the commencement of an anticipatory period of oscillation.

9. The combination of claim 8 wherein manually operable valvular means are provided to exhaust the pressurized gas from the ends of the second reactor controlling cylinder.

10. The combination of claim 8, wherein said piston of the first reactor controlling cylinder activates said piston valve through a resilient means.

11. A ship stabilizing apparatus according to claim 7, including a similarly operable second oscillatory sensor and a second similarly operable reactor mechanism, one sensor and reactor mechanism being responsive to rolling oscillations and the other sensor and reactor mechanism being responsive to pitching oscillations, both reactors being operable to transmit their respective efforts to said fin operating mechanism for integration thereby into one stabilizing effort.

12. A ship stabilizing apparatus according to claim 11, including a plurality of fins, a fin operating mechanism operatively connected to each of said fins and to both of the said reactor mechanisms.

13. The combination of claim 12, including means to override the actions of the said first and second oscillatory sensors, means to convert the normal effort delivered by said reactor mechanism responsive to pitching oscillations to the operating mechanism of one fin from positive to negative and the reverse, and manually operable means whereby each said reactor mechanism applies a positive effort to the operating mechanism of a first fin and a negative effort to the operating mechanism of a second fin, said manually operable means also applying said efforts to said respective fins in reverse manner.

14. The combination of claim 11, wherein said drive means of the fin operating mechanism comprises a movable member connected to the fin by linkage and consisting of a body having a shaft rotatable therein and lever means attached to said shaft, said lever means being operable by the efforts transmitted by the actuating pistons of the reactors to rotate said shaft and move bodily said movable member and thereby transmit tilting movement to the fin.

15. The combination of claim 7 including a first reactor controlling cylinder connected to a valvular means operated by said sensor, a piston housed in said first reactor controlling cylinder and mounted on a piston rod, a second reactor controlling cylinder having a piston valve therein to which the said piston rod is connected, the piston valve being operable to compress gas at either end of the second reactor controlling cylinder so as to arrest the movement of said piston valve, gas exhaust means automatically operable by said inertial member when the angular velocity of the ship's oscillation approaches a zero value, the piston valve movement being arrested until the said gas exhaust valve means exhausts gas from one end of said second reactor controlling cylinder and allows the piston valve to complete its movement to reverse the supply of motive liquid to the motive cylinder of the reactor and thereby reverse the anti-oscillatory effort applied to the fin operating mechanism at the commencement of an anticipatory period of oscillation.

16. The combination of claim 7, wherein the fin is slidable mounted in a fin carrier pivotally housed in a sea chest in the ship's side, and including controlling arms for operating the fin carrier connected to said drive means, and adjustment means for slidably moving said fin in said fin carrier between a fully extended position and fully retracted position at all angles of tilt of the fin carrier, said fin having at least one supporting stem in parallel relationship to the axis of tilt.

17. A ship stabilizing apparatus according to claim 16, wherein the adjustment means comprises at least one screw-threaded rod on said fin, internally screw-threaded gear means engageable with said screw-threaded rod, and a reversible motor drive connected to the gear means.

18. The combination of claim 17 and further comprising at least one tongue on said fin and housed in said fin carrier for slidable movement therein.

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