

Jan. 4, 1944.

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2,338,147

STABILIZING SYSTEM FOR SHIPS

Original Filed July 28, 1936

3 Sheets-Sheet 1

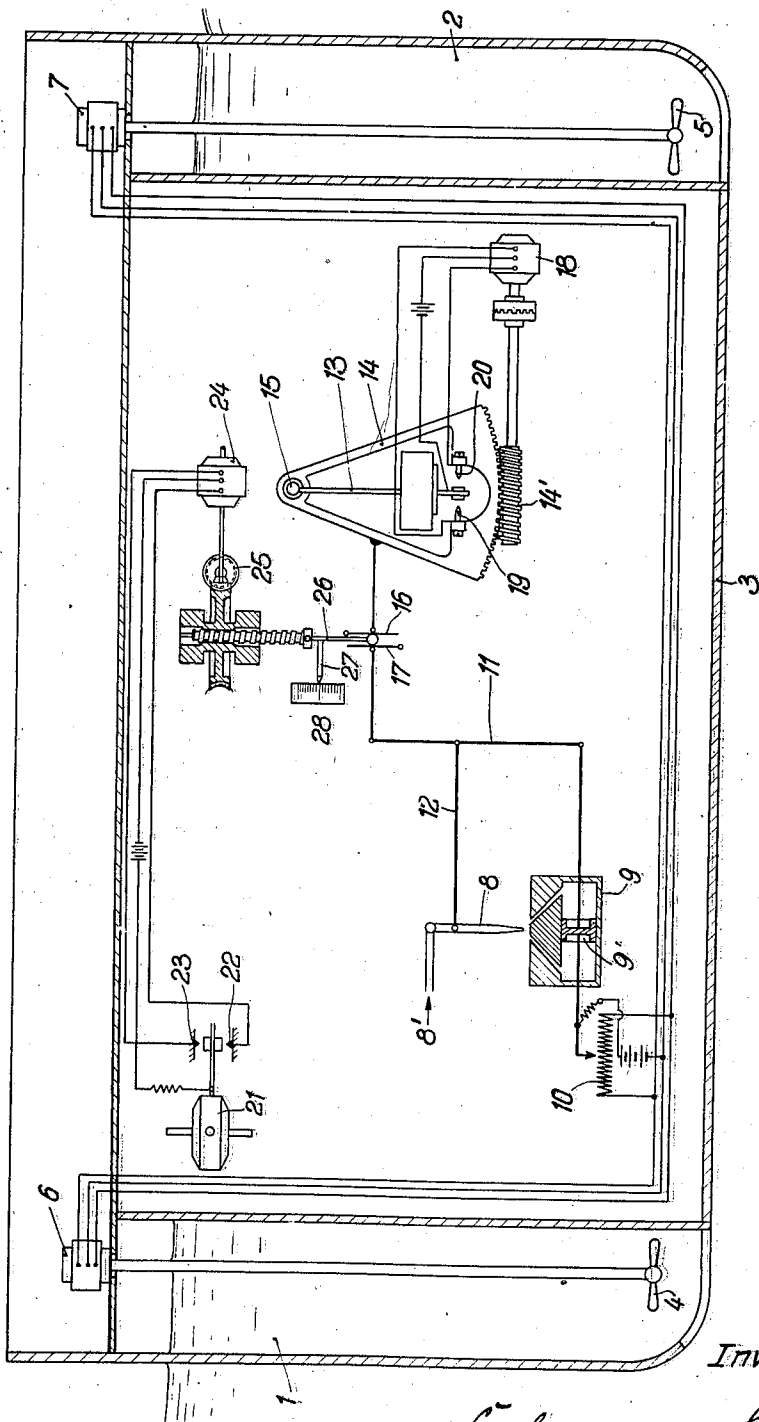


Fig. 1

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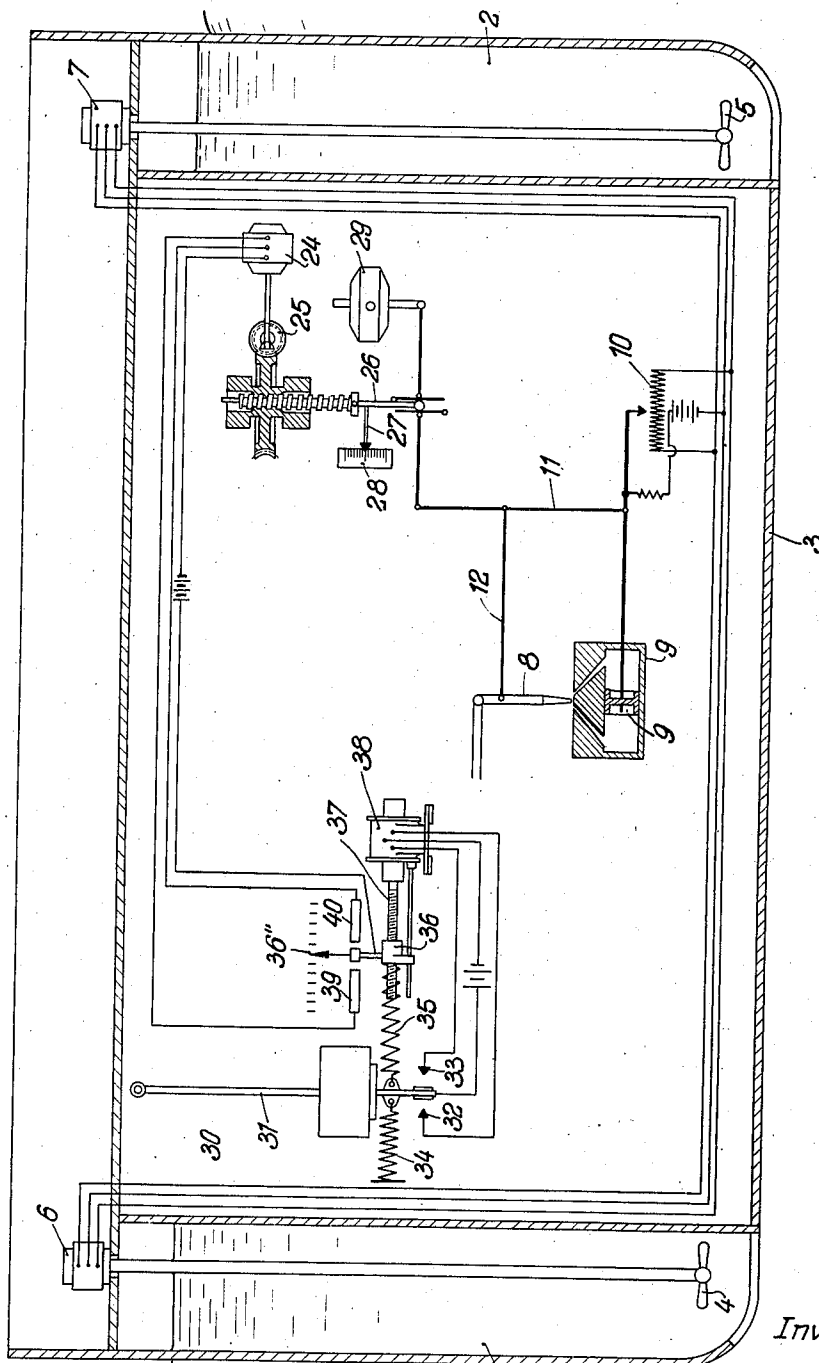


Fig. 2.

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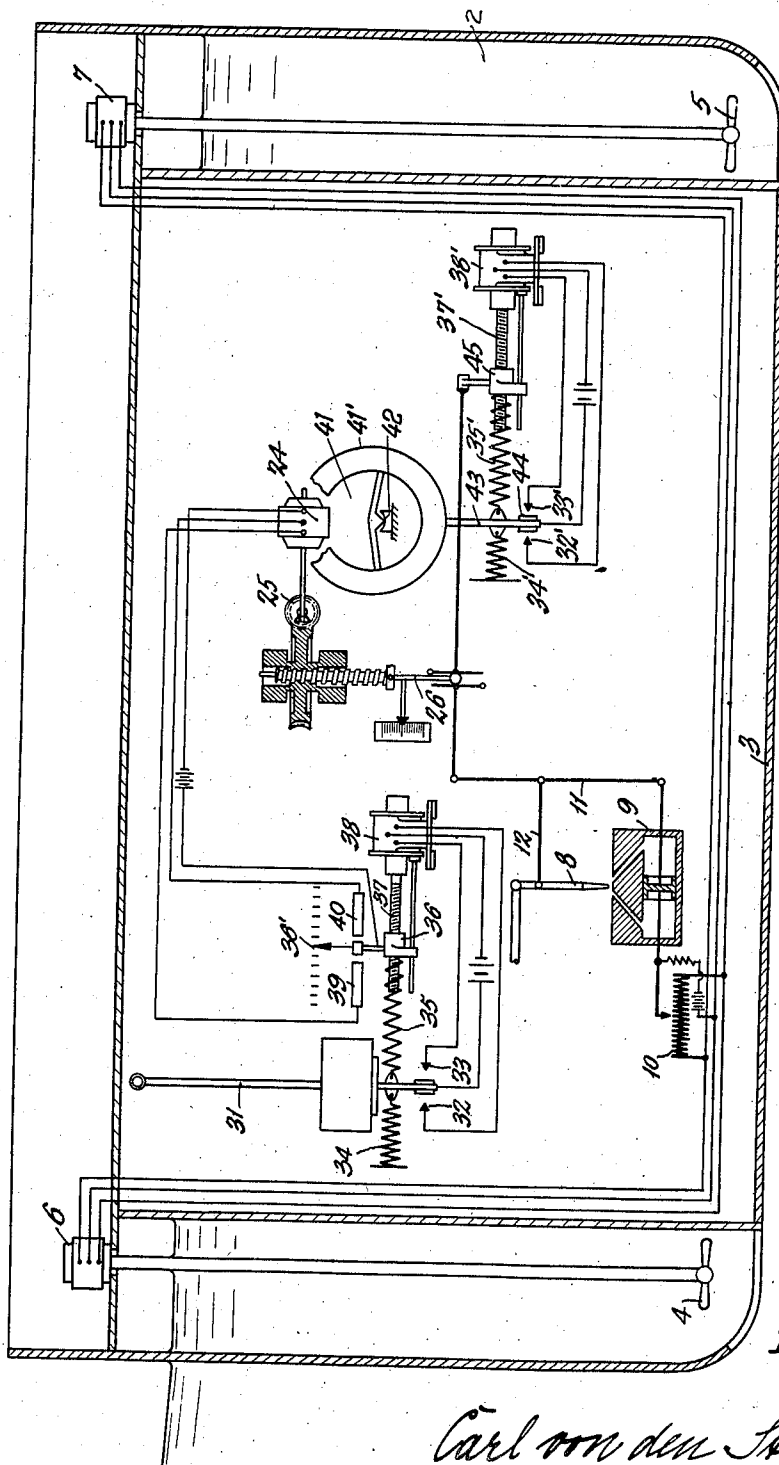


Fig. 3

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STABILIZING SYSTEM FOR SHIPS

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9 Claims. (Cl. 114—122)

This invention relates to a system for stabilizing ships.

Heretofore, as far as I am aware, it has been the practice to stabilize by means of moments exerted on the ship which were derived from the angle of deviation of the ship from its horizontal position and in some instances augmented by further impulses according to the angular velocity and acceleration. A prerequisite for the stabilizing action according to the conventional method is therefore a substantial deviation of the ship from its normal position. In other words, the stabilizer acts after outward disturbing influences have disturbed the state of stabilization, and the ship has assumed a list or tilt.

It is therefore an object of this invention to overcome the disadvantages of such delayed acting stabilization by devising a novel system instantaneously responding to outward disturbing conditions and counteracting the same before a substantial deviation has occurred.

This invention is based on the following consideration. An object floating on the water and exposed to the action of the waves will be subjected to a movement which, when observed from a vertical and stationary reference system, appears to be a semicircular movement. The waves do not only move the object up and down but also sideways, thereby moving the object approximately in a vertical circle. This movement is hereinafter called "orbital" movement.

A further consideration underlying this invention is the responsiveness to horizontal accelerations of the organ of equilibrium which is positioned in the internal part of the human ear. It has been shown by experiment that horizontal accelerations acting on the human body and thereby affecting the organ of equilibrium cause sea-sickness. Normally, the organ of equilibrium is only under the influence of the earth's acceleration force acting vertically and this state is regarded as the normal one and the one providing a feeling of comfort.

It is therefore a further object to stabilize a ship with regard to the resultant of all acceleration forces acting on the ship so that passengers on the ship will not be exposed to accelerations acting in any other than a vertical direction. This novel way of stabilizing will afford the further feature that movable objects on the ship do not move and shift in response to the rolling and pitching of the boat.

More particularly it is an object of this invention to provide a method of and an appa-

ratus for stabilizing a ship with respect to the direction of the sum of the acceleration forces.

Further aims, objects and advantages will appear from a consideration of the description which follows with the accompanying drawings showing embodiments of this invention for illustrative purposes. It is to be understood, however, that the description is not to be taken in a limiting sense, the scope of this invention being defined in the appended claims.

While in common usage the term "stabilizing" is understood to designate the action of maintaining an object stationary with regard to the true horizontal or vertical, I do not wish to employ the term in that limiting sense, but wish to designate thereby the action of maintaining the ship in a fixed relation with any predetermined reference system. As hereinbefore pointed out, the direction of the resultant of all acceleration forces acting on the ship is a direction of reference of particular importance. The stabilization with regard to the true horizon will in distinction hereinafter be called "horizontalization."

While normally a stabilization with regard to the resultant acceleration forces is the one offering a maximum of comfort to the passengers, horizontalization may be indispensable for special purposes as for instance, for observations, taking of bearings, and for purposes of ordnance.

Referring to the drawings:

Fig. 1 is a diagrammatic illustration of a non-delay horizontalizing system.

Fig. 2 is a modified form of the invention for stabilizing ships with respect to the resultant acceleration force.

Fig. 3 is a modified form of the device shown in Fig. 2.

In the system shown in Fig. 1 the device for exerting stabilizing moments on the ship is shown as comprising two tanks 1 and 2 positioned on either side of the ship 3 and communicating with the surrounding water. For filling the tanks and discharging water from the same power means are provided having in this embodiment the form of screws or propellers 4 and 5 operated by reversible motors 6 and 7. The weight of the charge of water in each tank exerts a static moment on the ship while the flow of water produced by the rotating propellers will cause dynamic moments to act on the ship.

The motors 6 and 7 are controlled by means of a relay shown as being of the well known jet-pipe type and comprising a movable jet-pipe 8

supplied with fluid under pressure from a suitable source (not shown) through a conduit 8'. The jet-pipe controls in well known manner the positions of a piston 9' of a servo-motor 9 operating a rheostat 10 inserted in the circuits of the motors 6 and 7 for controlling speed and direction of the latter. A restoring connection usual in servo motor systems is shown as arranged between the relay and servo-motor shown as having the form of levers or links 11 and 12.

For detecting outward disturbing influences on the ship a device responsive to the sum of the acceleration forces acting on the ship is provided and shown as having the form of a pendulum 13 swinging between stops or contacts 19 and 20 of a follow-up member 14. The pendulum has the tendency of aligning itself with the direction of the resultant acceleration force. Upon a relative displacement of the pendulum 13 and the follow-up member 14, one or the other of the contacts 19 and 20 is closed and the follow-up member turned by a reversible motor 18 and worm 14 to follow the position of the pendulum to restore the same to the neutral position. The resulting position of the follow-up member is transmitted as controlling impulse to the relay 8. The relay will thereupon cause a stabilizing force to be exerted on the ship to counteract the influence of the disturbing outward forces and thereby tend to maintain the ship in its original position.

Inasmuch as the pendulum 13 is restricted to small deflections a separate damping device can be dispensed with.

For supervising and checking the stabilizing action of the device responsive to acceleration forces a base line is provided having in the illustrated embodiment the form of a gyro vertical 21. The gyro vertical is connected to modify the stabilizing impulses of the pendulum device in a suitable manner such as by contacts 22 and 23 controlling a reversible motor 24. The motor operates a well known ratio varying device. The latter is shown as comprising levers 16 and 17 operatively connected by a slider 26 axially movable for adjustment by means of a threaded spindle which, in turn, is actuated by the motor through a suitable gear 25. The ratio in which the pendulum impulse is varied in magnitude may be read by means of a pointer 27 movable over a graduated scale 28.

The operation of the device is as follows:

Upon action of a disturbing force, imparting an acceleration to the ship, the pendulum 13 actuates the relay 8 and causes the power means 4, 5, 6, 7 to exert a counteracting and balancing force on the ship thereby anticipating a deviation of the ship from the horizontal position. In many instances, the counteracting force exerted by the power means is applied to the ship in the same direction as the wave moment or that of the disturbing forces. The counteraction of the device is therefore an instantaneous one. If now the stabilizing impulse happens to be too weak or too strong, the supervising or checking instrument, in a horizontalizing device a gyro vertical, for instance, responds to deviations of the ship from the predetermined position and modifies the controlling impulse of the pendulum by increasing or decreasing it in such manner that the ship remains in the stabilized or horizontalized position.

The feature of this device is that the checking action which is derived from a deviation from the normal position is a secondary one, only

modifying the balancing impulse which, for this reason, is not delayed.

As hereinbefore pointed out a quick acting horizontalizing device or system is especially valuable for measuring and observation purposes and for purposes of ordnance. A modified form of this invention for stabilizing ships with regard to the apparent vertical is shown in Fig. 2.

While for purposes of horizontalization the tilting action of the disturbing outward forces on the ship is altogether undesirable it is less so in a system for stabilizing with regard to the apparent vertical or the direction of the resultant acceleration force. In this instance the ship must be tilted, and in such a degree that the apparent vertical remains normal to the ship's deck. Inasmuch as the ship possesses a considerable inertia the ship will lag behind the changing direction of the outward forces. The stabilizing forces therefore are used to overcome the lag due to the inertia and will therefore normally act in the same direction as the disturbing influences.

In Fig. 2 the relay 8 is shown as controlled by an instrument responsive to movements of the ship about a substantially horizontal axis, shown as being a gyro-vertical 29. To take off an impulse from an instrument responsive to deviations of the ship is not disadvantageous as in the first place the ship is not supposed to remain stabilized with regard to the true horizontal and in the second the impulses are so modified as to eliminate the time delay between the action of the disturbing forces and the tilt resulting therefrom.

The supervising or checking instrument is a device 30 responsive to the direction of the resultant acceleration force, shown as including a pendulum 31. While in Fig. 1 the pendulum was equipped with a positional follow-up device in this figure a follow-up device based on the counterbalancing-force-principle is shown, including springs 34 and 35. Upon a deflection of the pendulum 31 one or the other of contacts 32 and 33 is closed, causing a reversible motor 38 to turn a threaded spindle 37 and displace a nut 36 thereon. The nut varies the tension of one spring thereby counterbalancing the action of the acceleration force on the pendulum. It is easily seen that the relative position of nut and spindle corresponds to the magnitude of the disturbing force acting on the pendulum. The nut may therefore be equipped with indicating means 36' and further with controlling contacts 39 and 40 for actuating the motor 24. The modification of the controlling impulse acting on the relay 8 is affected in the same manner as explained in connection with Fig. 1.

It has been found that the device shown in Fig. 2 operates in a very satisfactory manner provided that the movements of the waves are a harmonical function of the time. In case this condition is not fulfilled it is more advantageous to exert stabilizing moments on the ship in response to changes of the apparent vertical and the angular acceleration of the ship's movements, i. e. the second derivative of the movement with respect to the time. A modified form of the invention embodying this idea is shown in Fig. 3.

In Fig. 3 an angular acceleration device is shown at 41. The device is shown as having the form of an annular pendulum 41' suspended in its center of gravity at 42. The pendulum 41' is equipped with a conventional impulse take-off device hereinbefore described, and including an arm 43 secured to or integral with the an-

gular pendulum 41'. The arm is provided with contacts 44 movable between fixed contacts 32' and 33' for controlling a reversible motor 38'. The motor turns a spindle 37' on which a nut 45 travels varying the tension of springs 34' and 35'. The motor controlled by the contacts will tend to move the nut 45 into a position in which the tension of the springs is equal to the force exerted by the mass of the pendulum. The position of the nut thus becomes a measure of the force exerted by the pendulum. The positional impulse is transmitted to a ratio varying device 26' controlled by a pendulum 31. responsive to the direction of the resultant acceleration force. Like reference numerals in this figure refer to like parts described above in the description in connection with Fig. 2. In all other respects the function of the device shown in Fig. 3 corresponds with that of Fig. 2.

Obviously the present invention is not restricted to the particular embodiments thereof herein shown and described. Moreover it is not indispensable that all the features of this invention be used conjointly since they may be employed advantageously in various combinations and subcombinations.

What is claimed is:

1. In a stabilizing device for ships, the combination with means for exerting stabilizing torques on the ship, of first means responsive to deviations of the ship's vertical from the direction of the true vertical for creating controlling impulses proportional to such deviations, said deviation responsive means being connected to control said torque means in response to such impulses; second means responsive to deviations of the ship's vertical from the direction of the apparent vertical; and means controlled by said second means and so connected relative to said first means as to multiply said impulses by a factor which is proportional to such deviations of the ship's vertical from the apparent vertical, whereby the ship will be variably tilted and thereby align itself with the apparent vertical.

2. In a stabilizing device for ships, the combination with means for exerting stabilizing torques on the ship, of a gyro vertical responsive to deviations of the ship's vertical from the direction of the true vertical for creating controlling impulses proportional to such deviations, said gyro vertical being connected to control said torque means in response to such impulses; means including a pendulum following the direction of the apparent vertical; and means controlled by said pendulum means and so connected relative to said gyro vertical as to multiply said controlling impulses exerted on said torque means by a factor which is proportional to deviations of the ship's vertical from the apparent vertical, whereby the ship will be variably tilted and thereby align itself with the apparent vertical.

3. In a stabilizing system for ships, the combination with means for exerting stabilizing torques on the ship, of first means responsive to the rate of rate of movements of the ship about a substantially horizontal axis for creating controlling impulses proportional to the rate of rate of such movements, said first means being connected to control said torque means in response to such impulses; second means responsive to deviations of the ship's vertical from the direction of the apparent vertical; and means controlled by said second means and so connected relative to said first means as to multiply said

impulses by a factor which is proportional to such deviations of the ship's vertical from the apparent vertical, whereby the ship will be variably tilted and thereby align itself with the apparent vertical.

4. In a stabilizing system for ships, the combination with means for exerting stabilizing torques on the ship, of a first annular pendulum connected to control said stabilizing torque means and having a substantially horizontal axis of oscillation and including means for resiliently biasing said pendulum towards a normal position relatively to the ship, said first pendulum creating controlling impulses proportional to the rate of rate of movements of the ship about an axis parallel to the axis of oscillation of the ship; a second pendulum following the direction of the apparent vertical; and means controlled by said second pendulum and so connected relative to the first pendulum as to multiply said controlling impulses by a factor which is proportional to the deviations of the ship's vertical from the apparent vertical, whereby the ship will be variably tilted and thereby align itself with the apparent vertical.

5. In a stabilizing system for ships, the combination with means for exerting stabilizing torques on the ship, of first means responsive to deviations of the ship's vertical from the direction of the apparent vertical for creating controlling impulses proportional to such deviations, said deviation responsive means being connected to control said torque means in response to such impulses; and second means responsive to deviations of the ship's vertical from the direction of the true vertical; and means controlled by said second means and so connected relative to said first means as to multiply said controlling impulses by a factor which is proportional to the deviations of the ship's vertical from the true vertical, whereby the ship will be maintained aligned with the true vertical.

6. In a stabilizing system for ships, the combination with means for exerting stabilizing torques on the ship, of a pendulum following the direction of the apparent vertical and adapted to create controlling impulses proportional to inclinations of the ship relatively to the pendulum, said pendulum being connected to control said torque means in response to such impulses; a gyro vertical; and means controlled by said gyro vertical and so connected relative to said pendulum as to multiply said controlling impulses by a factor which is proportional to the deviations of the ship's vertical from the true vertical, whereby the ship will be maintained aligned with the true vertical.

7. A stabilizing device for ships comprising, in combination, power means for exerting stabilizing torques on the ship; a relay connected to said power means to actuate said power means in response to movements imparted to said relay; a first controlling means responsive to deviations of the ship's vertical from the direction of the apparent vertical arranged to create a controlling motion proportional to such deviations; a second controlling means responsive to movements of the ship about a substantially horizontal axis and arranged to create a controlling motion proportional to such movements of the ship; and an adjustable lever device connected to said relay for actuating said relay, said lever device being connected to increase or decrease an actuating movement, one of said controlling means being connected to actuate said lever

device, and the other controlling means being connected to adjust said lever device.

8. A stabilizing system for ships comprising, in combination, power means connected to exert stabilizing moments on the ship in the same direction as the moments exerted on the ship by the outward disturbing influences; an instrument responsive to deviations of the ship from a substantially horizontal axis; a second instrument responsive to deviations of the ship's vertical from the direction of the apparent vertical; a control device for said power means; means connecting one of said instruments to said control device to deliver primary controlling impulses; and means operatively connecting the other instrument to said control device to multiply the effect of the primary impulses by a factor proportional to the impulses delivered by said other instrument, whereby to impart variable tilting movements to the ship.

9. A stabilizing system for ships comprising, in combination, power means connected to exert stabilizing moments on the ship; means responsive to deviations of the ship from a substantially horizontal axis; means responsive to deviations of the ship's vertical from the direction of the apparent vertical; a relay connected to control said power means; means operatively connecting one of said deviation responsive means to said relay to deliver controlling impulses through said relay to said power means; and means operatively connecting the other deviation responsive means to said relay to vary the controlling impulses proportionately to the magnitude of the impulses delivered by said other deviation responsive means, whereby to impart variable tilting movements to the ship.

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