Dec. 29, 1936.

H. HORT

2,066,150

SHIP STABILIZER

Filed Nov. 19, 1932

Fig. 1.

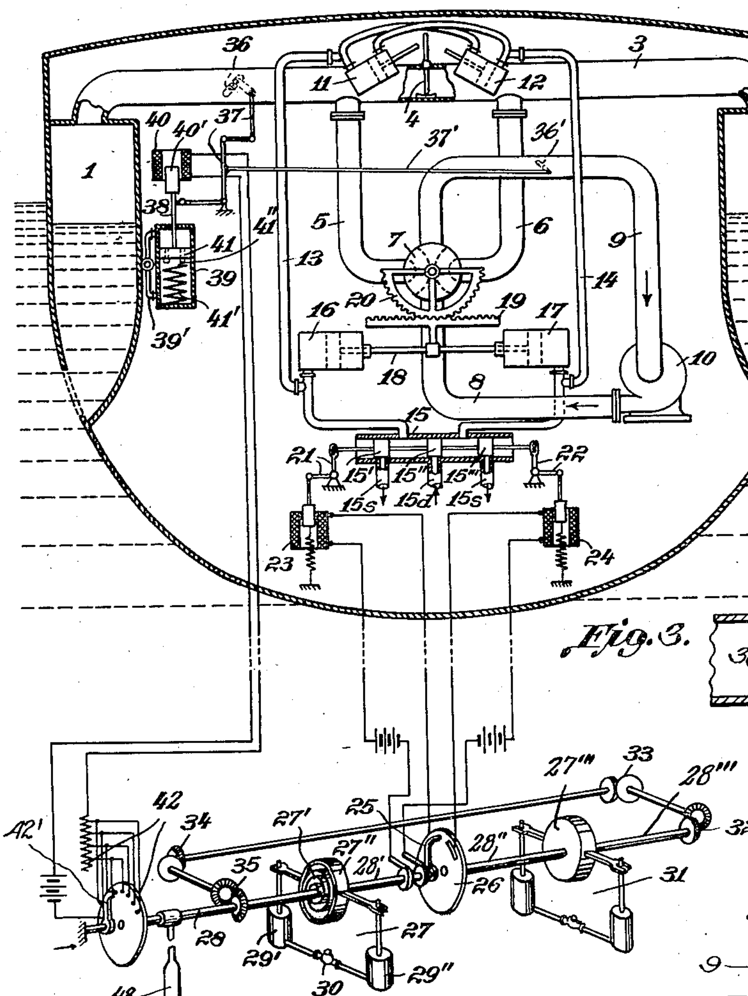


Fig. 3.

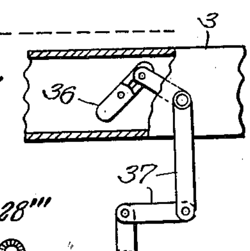
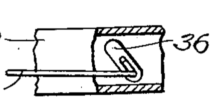


Fig. 4.



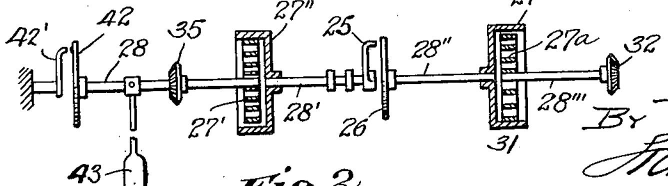


Fig. 2.

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2,066,150

UNITED STATES PATENT OFFICE

2,066,150

SHIP STABILIZER

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9 Claims. (Cl. 114—125)

My invention relates to ship stabilizers, and more specifically to a control system for the driving power of ship stabilizing or balancing masses, more particularly the liquid of anti-rolling tanks.

For controlling the driving power for shifting transversely of a ship, the stabilizing or balancing masses designed to counteract the rolling motion of the ship systems or mechanisms are already known in which the masses are shifted substantially proportionally to the magnitude of the angular velocity of the rolling motion in such a way that their to and fro motion lags in phase behind the rolling motion of the ship. When the ship is not rolling, the said masses are automatically shifted to the longitudinal center of the ship or equally distributed over both sides of the ship. This system or equipment is, however, of fairly complicated construction, and has, furthermore, the drawback that inclined positions of the ship caused by disturbing forces acting from one side, such as a list, centrifugal forces or the like, introduce irregularities into the entire control system, which in certain circumstances defeat the operation of the system. In another known system of moving the masses, the control mechanism drives the masses constantly towards the lower side of the ship as long as there exist periodic rolling motions, and such control mechanism drives the masses automatically towards the higher side of the ship if the ship has a list. The last-mentioned control is extremely simple and diversified. It has, however, the drawback that it always drives the masses into their limit positions, without the possibility of arresting them in an intermediate position, if desired.

The object of my invention is to improve the last-mentioned system of control. I attain this object by combining this system with an output regulator for the driving power employed, which regulates the power according to the magnitude of the rolling motion of the ship, in such a way that in fair weather the driving power is throttled down almost to zero and in heavy seas is switched in fully. In this way the result is furthermore obtained that the masses to be displaced may, if desired, be automatically distributed at opposite sides of the vessel at or about the midship section, of the sides outside the middle, if the forces to which the ship is subjected should demand this position of equilibrium.

My invention will be better understood by referring to the drawing affixed to my specification and forming part thereof. In the drawing, Fig. 1 shows an embodiment of my invention in diagrammatic representation, partly in section and partly in perspective view. Fig. 2 is an elevation, with parts in section, of certain elements appearing at the lower portion of Fig. 1, and Figs. 3 and 4 are enlarged sectional views of the valves 36 and 36′ respectively with the adjacent parts.

Referring to Fig. 1 of the drawing 1 and 2 are the two tanks communicating with the sea near their bottom and in customary manner provided along the side walls of the ship indicated in cross-section. The air spaces of these tanks are in communication with each other by the pipe 3, in which there is located the stop valve 4 and to which there is connected the force pipe and the suction pipes 8 and 9 respectively of a, for instance, continuously operating centrifugal fan 10, by means of the branch pipes 5 and 6, the connections being controlled by a two-way cock 7. The opening and closing of the stop valve 4 is effected by the piston rods of two hydraulic cylinders 11 and 12 which by the pipes 13 and 14 are so connected to the cylinder or casing 15 of a control slide valve, that the piston rod of the cylinder 11 is fully advanced and that of the cylinder 12 fully withdrawn if the control pistons 15′ to 15‴ are drawn to the right, and conversely the piston rod of cylinder 11 is fully withdrawn and that of cylinder 12 fully advanced if the pistons 15′ to 15‴ are in their left-hand end position. Parts 15_d and 15_s are the pipes connecting the control casing with suitable pressure liquid reservoirs.

To this control casing 15 are also connected the cylinders 16 and 17. On the piston rod 18 common to both cylinders is mounted a rack 19 which meshes with a toothed sector 20 keyed to the spindle of the two-way cock 7.

The setting of the control slide valve 15′, 15″, 15‴ is effected by the two bell-crank levers 21 and 22 by means of the electro-magnets 23 and 24, the cores of which are drawn into the solenoids against the resistance of springs when the magnets are energized. The moment of the reversal of the control slide must approximately coincide with the moment at which the rolling motion of the ship is reversed. In the design illustrated the switching on of the electro-magnets 23 and 24 and thereby the reversal of the control slide is effected by means of a switch 25, 26, whose contact lever 25 is set from the shaft 28 through a damping device 27, the shaft 28 being turned, for example in correspondence with the deflections of a pendulum 43 swinging at right angles to the longitudinal axis of the ship, by the rolling angle existing at the time.

The turning motions of the shaft 28 are transmitted to the inner end of a spiral spring 27′, the outer end of which is secured to the casing 27′′ of the spring of the damping device. The deflections of this casing 27′′ to which is also secured the shaft 28′ carrying the contact arm 25, are damped by two hydraulic cylinders 29′ and 29′′, for which purpose their piston rods engage the spring casing at the outside. The magnitude of the damping is so adjusted by the throttle valve 30 located in the connecting pipe between the two hydraulic cylinders, that the periodic movements of the spring casing and thus of the contact arm 25 lag in phase behind the movements of the shaft 28, which are proportional to the rolling angle, by approximately 90 degrees. The damping device 27 thus merely serves the purpose to displace the deflections of the shaft 28 by 90° in phase, so that the contact arm 25 performs a movement which in the case of a sinusoidal rolling motion corresponds approximately with the rolling angle velocity.

If, to start with, it is assumed that the contact disc is stationary, the contact arm 25 will in the case of a sinusoidal rolling motion just pass through the central position shown at the moment when the rolling motion is reversed. As long as the ship rolls in one direction, for instance in the clockwise direction, the magnet 23 will be connected in circuit, and as long as the ship rolls in the other direction, the magnet 24 will be energized. During the time when the ship rolls in a clockwise direction, the control slide 15′, 15′′, 15′′′ will be pulled to the left by the magnet 23. The piston rod of the cylinder 11 will consequently be pulled back and that of the cylinder 12 be pushed forward, so that the flap valve 4 will be able to turn to the right (contraclockwise), but not to the left from its closing position shown. The valve 4 may in this way allow a sudden pressure equalization to take place between the tanks 1 and 2 at the moment of the reversal of the rolling motion, i. e. in the case assumed at the beginning of the downward movement of the right-hand side of the ship. As soon as the downward movement of the tank 2 and the upward movement of the tank 1 have drained the tank 2 and filled the tank 1 to such an extent that the pressures are equal in the air spaces of the two tanks, the valve 4 closes automatically and is maintained in the closed position by the advanced piston rod of the cylinder 12, during the subsequent period during which the pressure in the tank 2 is higher than in tank 1. Only when the rolling motion of the ship in the clockwise direction reverses, the piston rod of the cylinder 12 is withdrawn and that of the cylinder 11 advanced due to the reversal of the control slide 15′, 15′′, 15′′′ so that a pressure equalization can take place from the left to the right and the valve 4 is then kept in its closed position.

As long as the ship rolls in the clockwise direction the piston rod 18 has been pushed into its left-hand limit position, so that the two-way cock 7 puts the suction pipe 9 in communication with the branch pipe 5 and the pressure pipe 8 in communication with the branch pipe 6. The blower 10 consequently conveys air during all this time from the tank 1 into the tank 2, whereby the water level is raised in the upwardly moving tank 1 and lowered in the downwardly moving tank 2, which means a continued increase of the active damping weight. As soon as the rolling motion is reversed and the ship commences to roll in a counter-clockwise direction, the two-way cock 7 is also reversed, so that the centrifugal fan 10 blows air from the tank 2 into the tank 1. The arrangement is such that the pressure equalization by the stop valve 4 taking place at the moment of reversal is not effected across the fan 10, for which reason this blower may be made comparatively small.

If the ship has a list or is inclined due to a leak, disposition of the cargo or the like, the amplitudes of the rolling motion toward opposite sides measured in relation to the horizontal position of the ship become of unequal size. The deflections of the contact lever 25 towards both sides would consequently be of different magnitude and duration. This would have the consequence that the water levels in both tanks and thus the effective damping forces in the two phases of the rolling of the ship would be so different that the average inclination of the ship would thereby be further increased. To avoid this the contact disc 26 is not stationary in the embodiment of my invention shown, but adapted to be adjusted by a second damping device 31 of exactly the same design as the first, which in its turn is adapted to be adjusted as regards periodicity from the shaft 28 in correspondence with the rolling motion, through bevel wheels 32, 33, 34 and 35. The contact disc 26 is secured to a shaft 28′′ rigid with the housing 27′′′ connected to the outer end of a helical spring 27a of the same character as the spring 27′, the inner end of such spring 27a being secured to a shaft 28′′′ on which one of the bevel wheels 32 is mounted rigidly. The throttling in the connecting pipe of the hydraulic cylinders of this damping device 31 is set so powerfully that the spring housing 27′′′ and thus the contact disc 26 are not affected at all by the short-time periodic movements, but merely in correspondence with the, on the average, permanently existing deflection of the shaft 28, which corresponds with the mean inclination of the ship. This amount corresponding with the mean inclination angle of the ship is thus transmitted from the spring housing 27′′′ of the damping device 31 to the contact disc 26, which means a displacement of the zero position of the contact lever 25. When the ship has no inclination or list, the rolling oscillations will involve equal swings to opposite sides of a vertical position, so that the direction of the pendulum 43 will be parallel to the upright axis of the ship at the moment when the ship passes through the middle point of its oscillation. Under these conditions, as stated above, owing to the powerful throttling by the valve in the connecting pipe of the damping device 31, the parts 27′′′, 28′′, and 26 will be held against rotation about their axis. Therefore, as long as the ship has no list, the contact disc 26 will remain stationary relatively to the ship during its rolling. If, however, the ship has a list, the (vertical) direction of the pendulum 43 will no longer be parallel to the upright axis of the ship at the moment when the ship passes through the middle point of its oscillation, and in consequence of these changed conditions, the parts 27′′′, 28′′ and 26 will gradually swing about their axis through an angle corresponding to list angle of the ship, the list angle being defined as the angle which the upright axis of the ship forms with a vertical line at the moment the ship passes through the middle point of its oscillation. In the case of such list, therefore, there will occur a shifting of the zero position of contact lever 25 relatively to the contact disc 26. This shifting or displacement may accurately correspond with the mean inclination (list angle) of the ship or be made so much greater that the fan 10 remains switched on longer during that half-period of the rolling motion in which the side of the ship which on the average is the lower side swings upwards, than during the following half-period during which this side of the ship is in downward motion. In this way I may effect an approximately perfect equalization of the mean inclination of the ship.

In the control system described above an adaptation of the damping moment to the strength of the rolling motions takes place in so far only as with the increasing rolling angle the tanks dip deeper into the sea and are consequently filled up and drained respectively to a greater extent. Otherwise a displacement of the masses of water between the two sides of the ship takes place, particularly by the centrifugal fan, which is independent of the state of the sea. If instead of the tanks containing bodies of water, trucks or other transversely displaceable solid masses should be employed for damping purposes, a control plant of the type described above would have the tendency to drive the masses continuously into the limit position, without the possibility of arresting them, if desired, in their middle position or adjacent thereto. In order to enable the displacement of the masses and thus the damping force to be adapted to the magnitude of the rolling motions of the ship, the following additional equipment is provided according to another feature of my invention:

In the pressure equalizing pipe 3 there is mounted a throttle valve 36, which through linkwork 37 is adjustably connected with the piston rod 38 of a hydraulic damping cylinder 39.

The piston rod itself is movable by electromagnetic action. The solenoid of the electromagnet 40 is energized in correspondence with the size or amplitude of the rolling angle at the time by a voltage divider 42 which adjusts itself according to the rolling angle, owing to its connection with shaft 28, and consequently exerts an upward pull on the core 40′ mounted on the piston rod. The piston 41 is easily able to follow the pull of the solenoid against the resistance of the spring 41′, because the non-return valves 41″ fitted into the piston offer no resistance worth mentioning to the flow of the liquid from the top downwards. In the opposite direction of motion of the piston, i. e. when it is pulled back by the spring 41′, the non-return valves tightly seal the piston so that the liquid displaced is obliged to take its way through the throttle valve of the by-pass pipe 39′. It is obvious that with a correspondingly strong throttling this retrieving motion of the piston by the spring can take place very slowly only; the piston will thus practically keep a position which corresponds approximately with the greatest amplitude of the rolling angle at the time. In this way the throttle valve 36 also receives a corresponding adjustment, so that it causes a regulation of the flow in the equalizing pipe 3 corresponding with the size or amplitude of the angle of roll, i. e. in correspondence with the magnitude of the disturbing forces acting on the ship.

It is, of course, possible to effect an output regulation in the conveying circulation system of the centrifugal blower 10, for instance as shown for the pipe 9 at 36′, 37′, where 36′ indicates a throttle valve located within the pipe 9 and 37′ indicates a rod or other suitable connection by which said throttle valve 36′ is operated from the linkwork 37. The drawing illustrates a construction in which the regulation of the output in the circulation of the blower 10, by means of the throttle valve 36′, is employed in addition to the output regulation first described (as by means of the throttle valve 36). I desire it to be understood, however, that instead of using both regulating devices as shown, one or the other of them may be used alone.

It will be understood that as long as the amplitude of the rolling angle remains constant, there will be no change in the position or adjustment of the throttle valves 36 and/or 36′, that is to say, the flow in the pipes 3 and/or 9 will remain unaltered. These valves 36, 36′ change their position or adjustment only in response to a change in the amplitude of the rolling angle, and as long as this angle remains constant, the rolling oscillations of the ship have no effect on the position or adjustment of said valves. On the other hand, the reversing device constituted by the parts 16, 17, 18, 19, 20, 7 is operated at each oscillation or rolling of the ship, irrespective of the amplitude of the rolling angle.

It will also be understood that the output regulation described may also be utilized for the control of solid damping masses, which are either moved by compressed air in a guide tunnel located transversely to the ship or run upon rails by an electric or hydraulic drive. These masses are usually controlled in such a way that in the case of sinusoidal rolling motions they continuously move downwards along the deck because in this case there is obtained the phase displacement of 90 degrees between the rolling of the ship and the damping mass required for obtaining the most efficient damping.

The output regulator may be perfected in its action in known manner by the fitting of an isostatically acting gearing. The arrangement may furthermore be such that the output regulator operates the throttle valves 36 and/or 36′ in well known manner through a servo motor. The output of the blower may also be regulated in such a way that under elimination of the throttle valves (36) the number of rotations of the blower or fan is in likewise known manner regulated by the output regulator.

What I claim as my invention and desire to secure by United States Letters Patent is:

1. In a ship stabilizer of the type in which stabilizing masses are shifted alternately in opposite directions in response to periodical oscillations of the ship, the combination of an actuating device for effecting a shifting of said masses in response to such oscillations of the ship, a controlling device for reversing the direction in which said actuating device shifts said masses, a separate controlling device movable principally in response to changes in the amplitude of the ship's oscillations to regulate the energy delivered by said actuating device, and means for substantially preventing operation of said last named controlling device in response to individual oscillations of the ship.

2. In a ship stabilizer of the type in which stabilizing masses are shifted alternately in opposite directions in response to periodical oscillations of the ship, the combination of an actuating device for effecting a shifting of said masses in response to such oscillations of the ship, an electromagnetic controlling device for reversing the direction in which said actuating device shifts said masses, a separate electromagnetic controlling device movable principally in response to changes in the amplitude of the ship's oscilla-

tions to regulate the energy delivered by said actuating device, means for substantially preventing operation of said last named controlling device in response to individual oscillations of the ship, and a device, responsive to oscillations of the ship, for controlling said two controlling devices.

3. In a ship stabilizer, liquid tanks located on opposite sides of the axis about which the ship is to be stabilized, said tanks being adapted to contain air in their upper portions, a conduit connecting the upper portions of tanks located on opposite sides of said axis, an air-propelling device connected with said conduit, a two-way cock interposed in the connection of said propelling device with said conduit and adapted in response to oscillations of the ship about said axis to reverse the direction in which said propelling device acts on the air in said tanks, and a throttle valve located in said conduit and movable principally in response to changes in the amplitude of the ship's oscillations, to regulate the air in the respective tanks.

4. In a ship stabilizer, liquid tanks located on opposite sides of the axis about which the ship is to be stabilized, said tanks being adapted to contain air in their upper portions, a conduit connecting the upper portions of tanks located on opposite sides of said axis, an air-propelling device connected with said conduit, a two-way cock interposed in the connection of said propelling device with said conduit and adapted to reverse the direction in which said propelling device acts on the air in said tanks, an electromagnetic controlling device for changing the position of said cock, a throttle valve located in said conduit, a separate electromagnetic controlling device for changing the position of said throttle valve correspondingly to the magnitude of the oscillations of the ship, and a device, responsive to oscillations of the ship, governing the adjustment of the electromagnetic device which controls the position of said throttle valve.

5. In a ship stabilizer, liquid tanks located on opposite sides of the axis about which the ship is to be stabilized, said tanks being adapted to contain air in their upper portions, a conduit connecting the upper portions of tanks located on opposite sides of said axis, an air-propelling device connected with said conduit, a two-way cock interposed in the connection of said propelling device with said conduit and adapted to reverse the direction in which said propelling device acts on the air in said tanks, an electromagnetic controlling device for changing the position of said cock, a throttle valve located in said conduit, an electromagnetic controlling device for changing the position of said throttle valve, said last-mentioned device including a core movable in a predetermined direction upon the energizing of said device and a spring tending to move said core in the opposite direction, a pendulum the position of which relatively to the ship varies in response to the oscillations of the ship, and means controlled by said pendulum for varying the energization of the electromagnetic device which controls the position of said throttle valve.

6. In a ship stabilizer, liquid tanks located on opposite sides of the axis about which the ship is to be stabilized, said tanks being adapted to contain air in their upper portions, a conduit connecting the upper portions of the tanks located on opposite sides of said axis, an air-propelling device connected with said conduit, a two-way cock interposed in the connection of said propelling device with said conduit and adapted to reverse the direction in which said propelling device acts on the air in said tanks, a throttle valve located in said conduit, another throttle valve located in the connection of said propelling device with said conduit, an electromagnetic controlling device for simultaneously changing the position of both throttle valves, a device responsive to oscillations of the ship, and means, controlled by said last-mentioned device, for varying the energization of said electromagnetic device in correspondence to the magnitude of said oscillations.

7. In a ship stabilizer, liquid tanks located on opposite sides of the axis about which the ship is to be stabilized, said tanks being adapted to contain air in their upper portions, a conduit connecting the upper portions of tanks located on opposite sides of said axis, an air-propelling device connected with said conduit, a two-way cock interposed in the connection of said propelling device with said conduit and adapted, in response to oscillations of the ship about said axis, to reverse the direction in which said propelling device acts on the air in said tanks, and a throttle valve located in the connection of said propelling device with said conduit and movable principally in response to changes in the amplitude of the ship's oscillations, to regulate the air in the respective tanks.

8. In a ship stabilizer, liquid tanks located on opposite sides of the axis about which the ship is to be stabilized, said tanks being adapted to contain air in their upper portions, a conduit connecting the upper portions of tanks located on opposite sides of said axis, an air-propelling device connected with said conduit, a two-way cock interposed in the connection of said propelling device with said conduit and adapted to reverse the direction in which said propelling device acts on the air in said tanks, a throttle valve in the connection of said propelling device with said conduit, an electromagnetic device for changing the position of said throttle valve, a device responsive to oscillations of the ship, and means, controlled by said last-mentioned device, for varying the energization of said electromagnetic device in correspondence to the magnitude of said oscillations.

9. In a ship stabilizer of the type in which stabilizing masses are shifted alternately in opposite directions in response to periodical oscillations of the ship, the combination of an actuating device for effecting a shifting of said masses in response to such oscillations of the ship, controlling means for reversing, in a rhythm corresponding to that of said oscillations, the direction in which said actuating device shifts said masses and means for regulating the energy delivered by said actuating device, said regulating means being responsive principally to changes in the amplitude of the ship's oscillations, and means for substantially preventing operation of said regulating means in response to individual oscillations of the ship.

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