Dec. 14, 1926. 1,610,853

J. FIEUX

ANTIROLLING APPARATUS

Filed Sept. 24, 1925 2 Sheets-Sheet 1

Fig. 1.

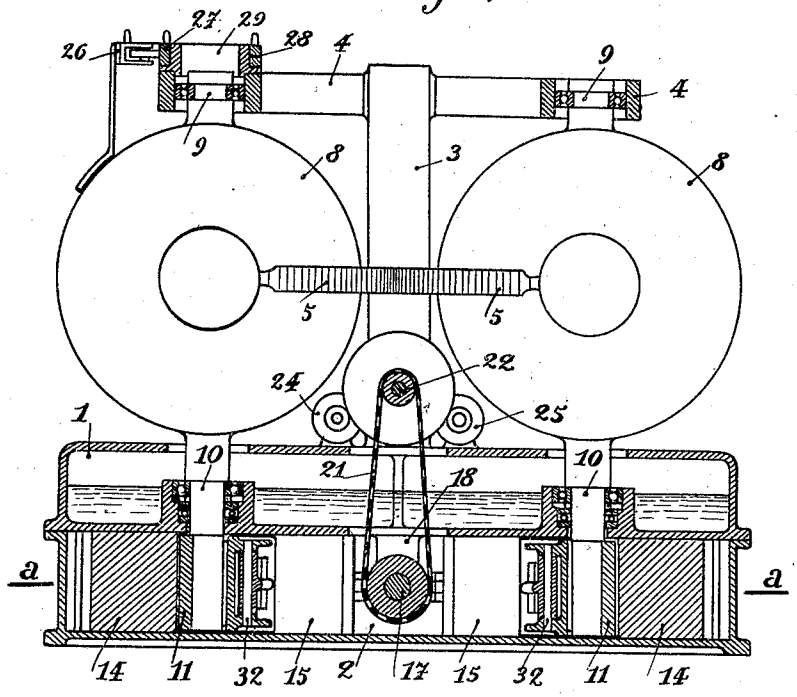
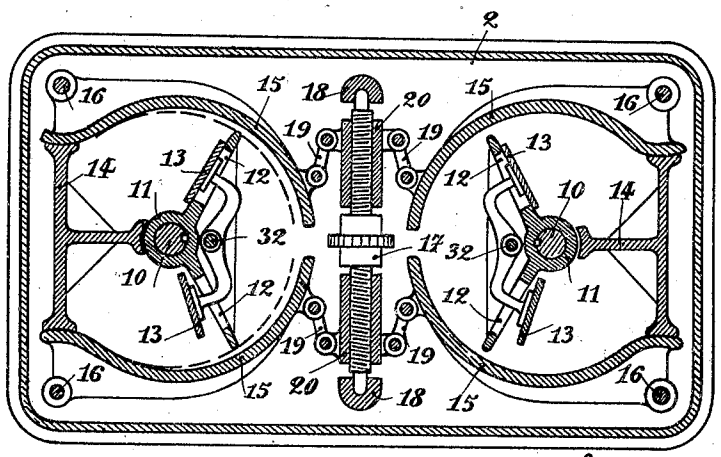


Fig. 2.



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Fig. 3.

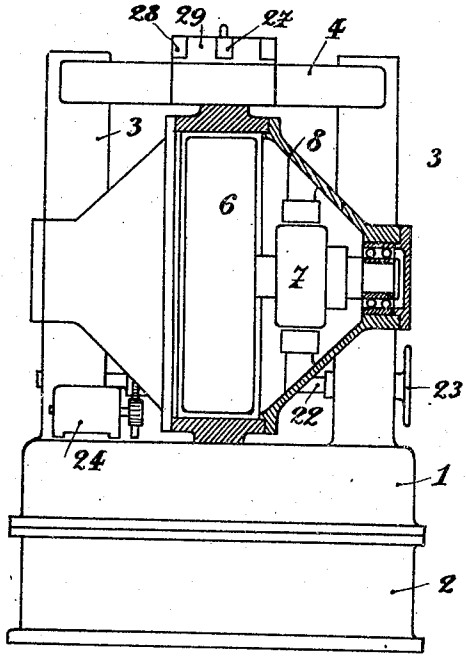


Fig. 5.

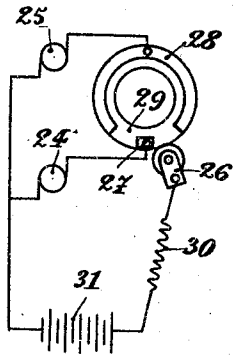
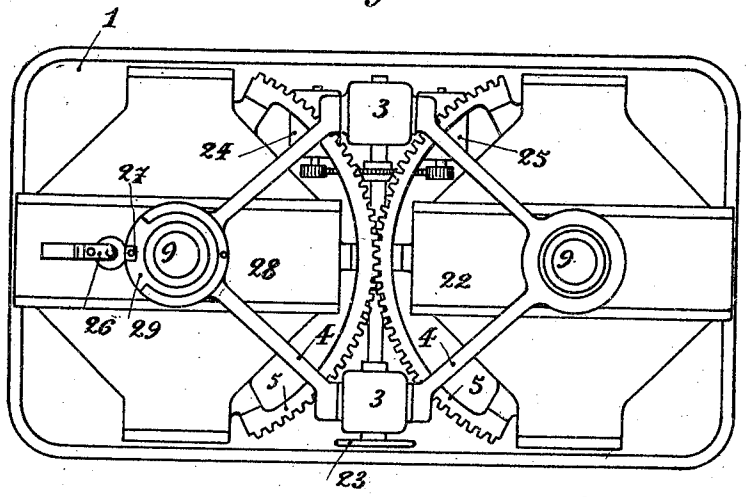


Fig. 4.



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UNITED STATES PATENT OFFICE.

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ANTIROLLING APPARATUS.

Application filed September 24, 1925, Serial No. 58,350, and in France November 13, 1924.

This invention relates to an arrangement for damping the deviations of gyroscopes employed on board vessels for reducing the amount of rolling.

This arrangement enables the efficiency of anti-rolling gyroscopes of the passive type, which are of a more simple and robust construction than devices subject to a forced precession, to be increased.

It consists of a double acting hydraulic brake, acting upon the precession trunnion of the gyroscope, that is to say upon the oscillation trunnion of the casing of the rotating mass of the gyroscope and utilizing the loss of charge of a liquid flowing through one or more freely open orifices, the section of which decreases gradually as the deviation occurs in either direction.

The useful effect is obtained by valve orifices, the movement of the closing members of which practically nullifies the counterpressure necessary for the re-entry of the liquid into the brake chambers. In other words, in order that the damping of the movement of precession which the gyroscope is given by the rolling couple shall not be opposed arbitrarily by the counterpressure exerted upon the piston or diaphragm of the brake on account of the flow of liquid behind the piston or diaphragm, the device comprises an arrangement of valves the movement of which, by assisting the circulation of the liquid behind the said piston or diaphragm, practically nullifies the said counterpressure.

According to the invention a device is also provided which enables the mean value of the section of flow to be varied, so as to enable the oscillation of the gyroscopic arrangement to maintain the largest desirable amplitude, whatever be the state of the sea and the conditions of loading of the vessel. By means of this device the displacement of one of the members between which the liquid is squeezed is obtained; this displacement is effected either by hand or, preferably, automatically.

The displacement is effected automatically, for example, by means of two electro-motors arranged in such a way that when one of them is brought into action an increase is produced, while when the other is brought into action a reduction is effected, in the mean section of flow. An arrangement of switches establishes the flow of the current supplying the first electromotor, when the oscillating arrangement is in a certain zone of its mean position relatively to the frame, and the flow of the supply current of the second electro-motor when the oscillating arrangement is in the neighbourhood of the extreme positions.

The new damping arrangement combined with the devices described above possesses the advantage of enabling the anti-rolling apparatus to develop, under all circumstances, the best mean reaction couple it is capable of providing, in order to check the rolling of the vessel, and to stabilize the hull in a practical manner when the state of the sea makes it possible.

Moreover, by allowing the precession, for the same speed of rolling, to move the oscillating arrangement more rapidly towards its mean position than it moves it away from the latter a connection is produced between this arrangement and the frame, which connection may be compared, in the returning effects it produces, to spring and counterweight connections, but has not like the latter the disadvantage of increasing the phase difference between the precession and the rolling.

It is known that this phase difference also depends upon the inertia of the oscillating arrangement itself and that the effect of it is to reduce the mean damping power of the anti-rolling apparatus. By means of its comparatively weak action at the commencement of the deviation, the brake arrangement forming the subject of the invention enables the speed of precession to reach its maximum more rapidly, which maximum approaches, in time, the corresponding maximum speed of rolling; it thus reduces the effect of the phase difference between the two damping factors.

When the movements of pitching and turning are likely to attain relatively high angular velocities, particularly in the case of small vessels, it is preferable to fit the new damping arrangement to anti-rolling apparatus comprising two conjugated gyroscopes having opposing precessions.

This form of construction is described hereinafter by way of example, and illustrated in the accompanying drawings, in which:

Figure 1 is a sectional elevation of the arrangement embodying the invention, the

section being taken along the plane of the axes of precession.

Figure 2 is a plan section of the damping arrangement taken along *a—a* in Fig. 1.

Figure 3 is a side view of the general arrangement of the anti-rolling device, the gyroscope casing being shown partly in section.

Figure 4 is an outside view of the general arrangement of the apparatus, shown in plan.

Figure 5 is an arrangement diagram of the electrical connections of the automatic controlling arrangement.

An upper tank 1 forming a cover for a lower tank 2 forms, together with two columns 3 and two guides 4 carried by the latter, the precession frame of two gyroscopes coupled together by means of toothed sectors 5. Each gyroscope comprises a rotating mass 6 mounted upon the shaft of an electric motor 7, and casing 8 carrying the stator of the motor and adapted to oscillate upon the precession frame, by means of trunnions 9 and 10 mounted in ball bearings, about an axis perpendicular to the axis of rotation of the mass 6.

The arrangement embodying the invention proper comprises more particularly, preferably for each gyroscope the following members:

The piston or diaphragn of the double acting brake, consists of a butterfly valve member 11 mounted upon an extended portion of the trunnion 10 and comprising two blades in each of which is formed an orifice 12 adapted to be closed by a valve 13. The two valves may be coupled together, that is to say they may be rigidly attached to each other, the whole member formed by them being movable about a pivot 32 carried by the butterfly member 11 and disposed symmetrically between the orifices 12. The angle between the two valves rigidly attached together is greater than the angle formed between the planes of the orifices 12, so that when either of these orifices is closed, the other is at its maximum opening. The butterfly member 11 moves without friction in a chamber enclosed above and below by the ends of the lower tank, and bounded on its sides by a fixed partition 14 and two movable partitions 15. Each movable wall is adapted to turn about a shaft 16 rigidly attached to the frame and situated practically in alignment with the corresponding blade when the latter has arrived at the end of its damping stroke.

A transverse shaft 17, turning in supports 18 attached to the frame, controls the symmetrical angular displacement of the movable partitions 15, by means of links 19 pivotally connected to these partitions and nuts 20 tapped one with a left hand and the other with a right hand thread, through which pass the corresponding screwthreaded parts of the shaft 17. This shaft is driven in either direction by a chain 21, from another shaft 22 mounted in the frame columns and actuated either by hand, by means of a hand wheel 23, or automatically by the two electric motors 24 and 25 developing opposing couples.

These motors are supplied with current, intermittently, when a trolley 26, carried upon one of the casings 8, from which it is insulated, passes over one or the other of two conductors 27 and 28 upon an insulating crown 29 provided upon the guide 4. A flexible conductor 30 (Fig. 5) connects the trolley 26 to one of the terminals of a source of voltage 31, fixed to the frame The conductor 27 is connected to the motor 24 which operates the separation of the movable partitions 15, while the conductor 28, is connected to the motor 25 which closes these partitions together.

The anti-rolling device described above must be mounted upon the hull in such a way that the plane of its axis containing the precession axes is parallel to the longitudinal axis of the vessel. A liquid, which may be a mixture of water and glycerine, occupies the whole space remaining free in the lower tank and reaches a certain level in the upper tank in order to form a reserve and sufficient charge.

It is well known in the art how the action of any gyroscope of the passive type aids action of the inertia of the boat itself in opposing the disturbing forces tending to destroy the transverse equilibrium and to produce rolling. It is equally well known that the antagonistic effect produced by the action of the gyroscope is utilized particularly because the movements of precession of the same are so freely produced.

Now the action of the gyroscope is delayed because of its own inertia and the passive resistance of its suspension means a connection with the hull, and it will readily be seen that the arrangement of the double acting brake herein described reduces the retardation to a minimum.

With this apparatus, the brake operates with a resistance which, at the start, is practically nothing, being due only to very weak liquid resistance, the movement of the member 11 being small. Therefore, the setting in motion of the braking apparatus takes place with great facility, and without preventing the gyroscope from acting as would be the case with the usual system of braking whereof the antagonistic effect, too prolonged at the start, paralyzes the action of the gyroscope. As has already been said, the movement of rolling tends to displace one of the blades of the member 11 toward the fixed wall 14, and the corresponding valve 13 closes at once due to its own inertia

and the inertia of the displaced liquid; from then on the entire blade 11, 13 acts like a piston against the liquid, which must pass between the wall 15 and the edge of the blade. As before explained, this orifice has a decreasing cross-section due to the action of motor 25. At the same time the valve 13 of the other blade 11, which is then closest to wall 14 with the minimum orifice opening between it and the wall, is open, permitting the liquid to reenter freely the chamber between the blade 11 and wall 14, of which the volume increases progressively as precession continues.

On the braking side of member 11, the orifice decreases progressively until practically zero, when the system 11, 13 has reached the maximum angle permitted for the amplitude of precession.

It will be seen that the system assures the gyroscope a precession of strictly limited amplitude, the apparatus being now ready to begin an inverse precession, on the effect of a surge or movement of return which the force exercises on the ship. Now as soon as any tendency to such movement is produced, there is a separation between the blade 11 (which until then compressed the liquid) and its valve 13, so that the liquid can freely flow through the orifice 12 thus opened. On the other hand, the orifice 12 of the other blade is immediately closed by the corresponding valve 13.

The return of the gyroscope, from its extreme position in one direction, to its mean position, in other words a change in the direction of the precession, is therefore made practically without resistance, by the fact that there is a separation between the blade 11 and the corresponding valve 13, which together have constituted a diaphragm, as soon as there appears the least tendency toward change in the direction of precession. This action of the valve 13, its separation from blade 11, assures a flow orifice or passage with large cross-section, whatever may be, at that moment, the position of the walls 15 and consequently the value of the mean section of orifice between blade 11 and wall 15, determined by the action of the motors 24 and 25.

Claims:—

1. An anti-rolling apparatus comprising, in combination, gyroscopes of the passive type, and means for controlling the movement of said gyroscopes including liquid containers, diaphragm members operatively secured to the precession trunnions of said gyroscopes and movable within said containers, and flow orifices for passing said liquid around said diaphragm members, said orifices being formed between said members and the walls of said containers, and being such that their mean section decreases from maximum to minimum when said members are displaced in the direction of precession.

2. An anti-rolling apparatus comprising, in combination, gyroscopes of the passive type, and means for controlling the movement of said gyroscopes including liquid containers, diaphragm members operatively connected to the precession trunnions of said gyroscopes and movable within said containers, flow orifices between said diaphragm members and the walls of said containers, and means for varying the mean section of said orifices.

3. An anti-rolling apparatus comprising, in combination, gyroscopes of the passive type, and means for controlling the movement of said gyroscopes including substantially circular liquid containers, a pair of diaphragm members in each of said containers, said members being operatively connected to the precession trunnions of said gyroscopes and being rotatable therewith, flow orifices for said liquid formed between the periphery of said diaphragm members and the walls of said containers, and means for moving said walls to vary the mean section of said orifices.

4. An anti-rolling apparatus comprising, in combination, gyroscopes of the passive type, and means for controlling the movement of said gyroscopes including substantially circular liquid containers, a pair of diaphragm members in each of said containers operatively connected to the precession trunnions of said gyroscopes and rotatable therewith, valve means on said diaphragm members adapted to be operated by the pressure of said liquid, means for associating said valve means whereby when one valve is open the other is closed, flow orifices for said liquid formed between the perphery of said diaphragm members and the walls of said containers, and means for moving said walls to vary the mean section of said orifices.

5. An anti-rolling apparatus comprising, in combination, a gyroscope of the passive type, and means for controlling the movement of said gyroscope including a substantially circular liquid container having pivotally mounted walls, a pair of diaphragm members rotatably mounted in said container and actuated by the precession trunnion of said gyroscope, valve means on said diaphragm members, flow orifices for said liquid formed between the periphery of said members and the walls of said container, and means including electric motors actuated by the precession trunnions of said gyroscope for moving said walls to vary the section of said orifices.

6. In apparatus of the class described including a gyroscope, hydraulic means for controlling the precession of said gyroscope comprising a substantially circular liquid chamber having movable walls, a pair of

diaphragm members rotatable in said container and actuated by the precession of said gyroscope, valve means on said members adapted to be operated by liquid pressure and so associated that when one is closed the other is open, flow orifices between the periphery of said members and said walls, and means for moving said walls including electric motors actuated by the precession of said gyroscope whereby the section of said orifices is decreased as the precession reaches a predetermined amplitude in either direction and increased when said gyroscope reaches its central position.

7. In apparatus of the class described including a gyroscope, the combination of a hydraulic brake operatively connected to the precession trunnion of said gyroscope and electrically operated means actuated by the precession of said gyroscope for increasing the resistance of said brake as said precession progresses in either direction from the center.

8. In apparatus of the class described including a gyroscope, the combination of a hydraulic brake mechanism having liquid flow orifices and being operatively connected to the precession trunnion of said gyroscope, and electrically actuated means controlled by the precession of said gyroscope for varying the section of said orifices whereby the resistance of said brake is increased as said precession progresses in either direction from the center and is decreased as the gyroscope passes through its central position.

9. In apparatus of the class described including a gyroscope, a hydraulic brake mechanism operatively connected to said gyroscope, said mechanism having liquid flow orifices, valve means regulating said orifices to oppose hydraulic pressure to movement of said mechanism in either direction and to relieve said pressure at the instant of reversing such motion, and means regulating the mean section of said orifices in accordance with the amplitude of precession of said gyroscope.

10. In apparatus of the class described including a gyroscope, a double-acting hydraulic brake mechanism operatively connected to a trunnion of said gyroscope, said mechanism having a plurality of liquid flow orifices, valve means for said orifices adapted to close during movement of said mechanism in either direction and to open at the instant the direction of movement is reversed, and means regulating the mean section of said orifices in accordance with the amplitude of precession.

In testimony whereof I have signed this specification.

JEAN FIEUX.