April 14, 1931. A. E. SCHEIN 1,800,408

ROLL AND PITCH REDUCING DEVICE FOR SHIPS

Filed Jan. 11, 1928 4 Sheets-Sheet 1

Fig. 1.

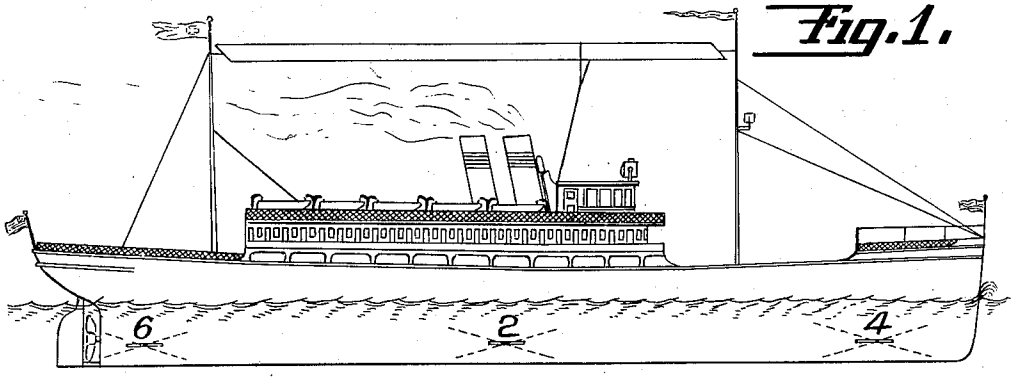


Fig. 2.

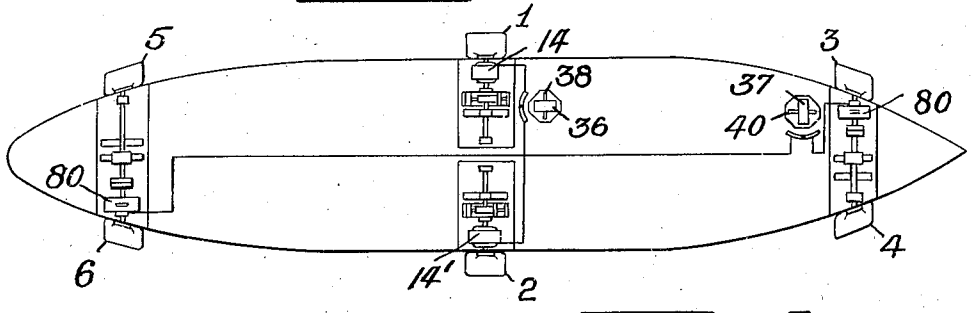


Fig. 3.

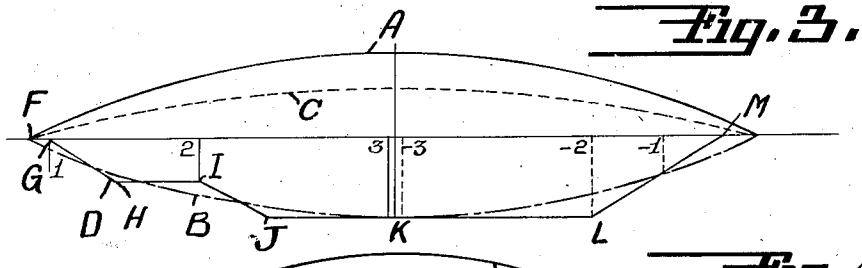
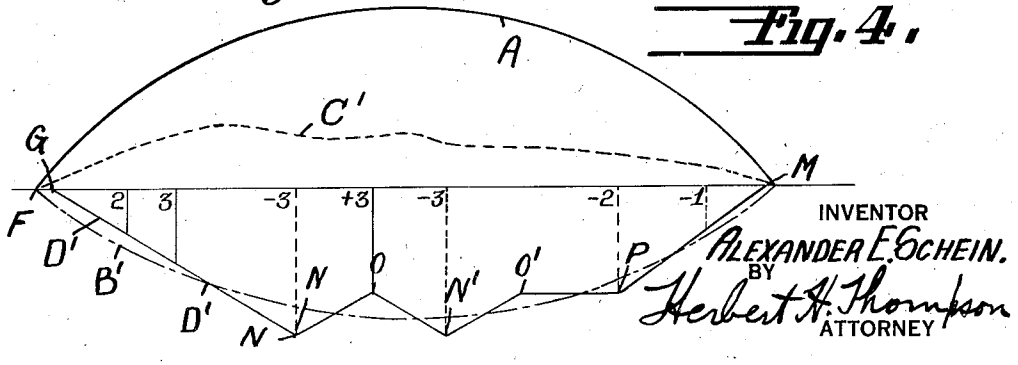


Fig. 4.



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ROLL AND PITCH REDUCING DEVICE FOR SHIPS

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Fig. 5.

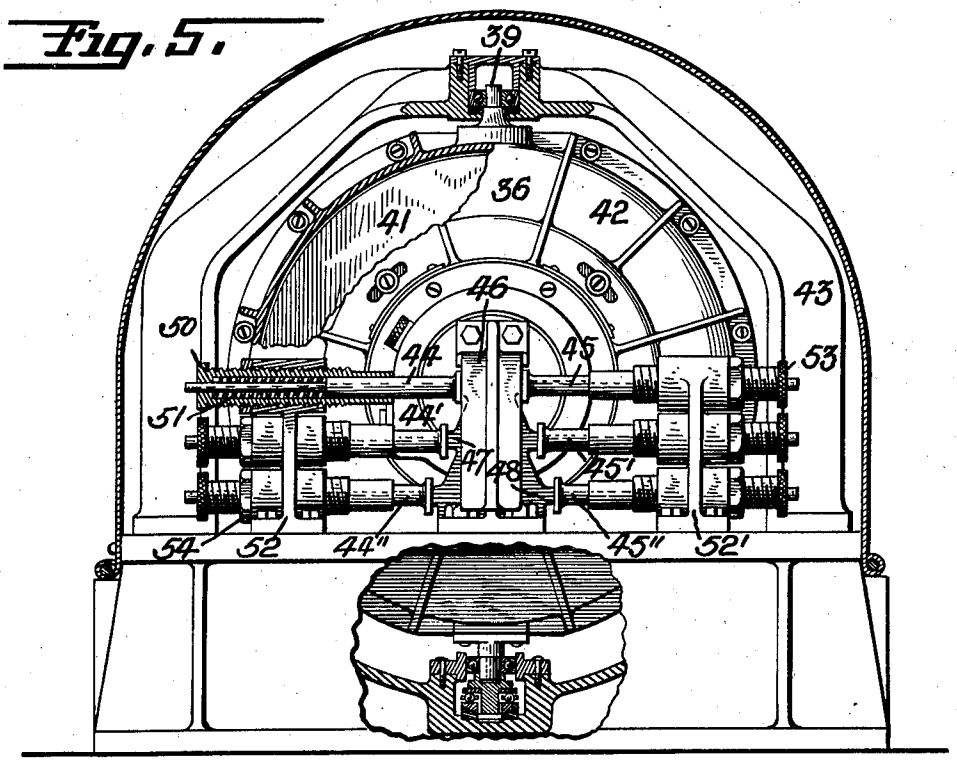

Fig. 6.

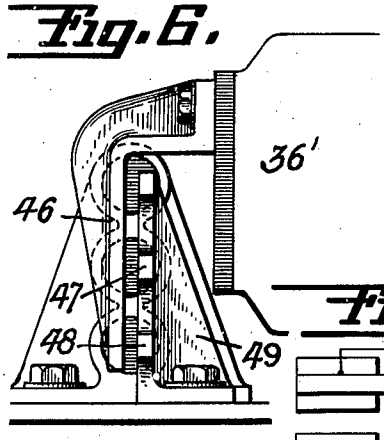

Fig. 7.

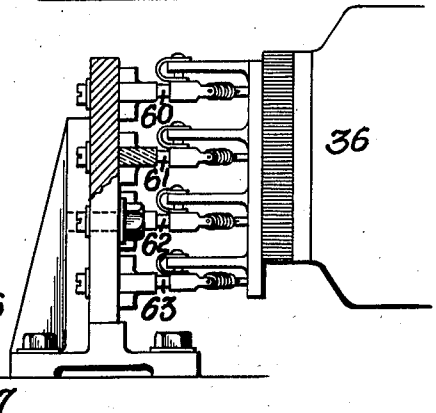

Fig. 8.

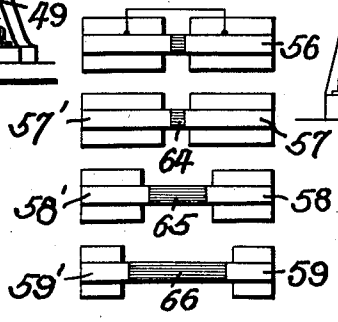

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Fig. 9.

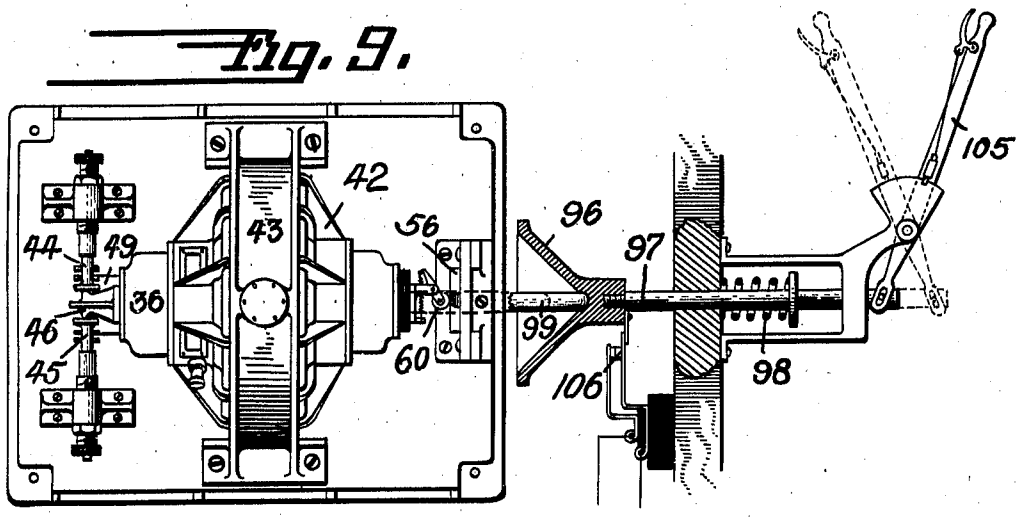


Fig. 10.

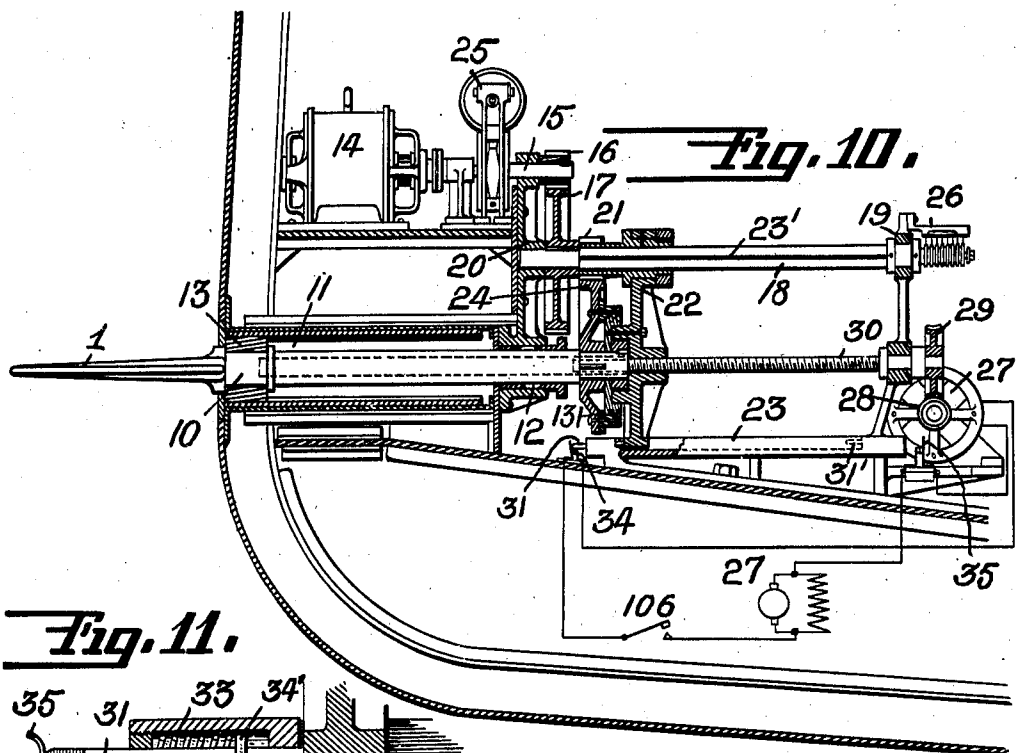
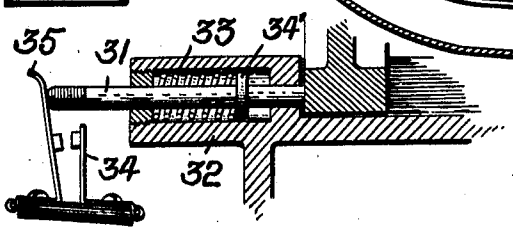


Fig. 11.



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ROLL AND PITCH REDUCING DEVICE FOR SHIPS

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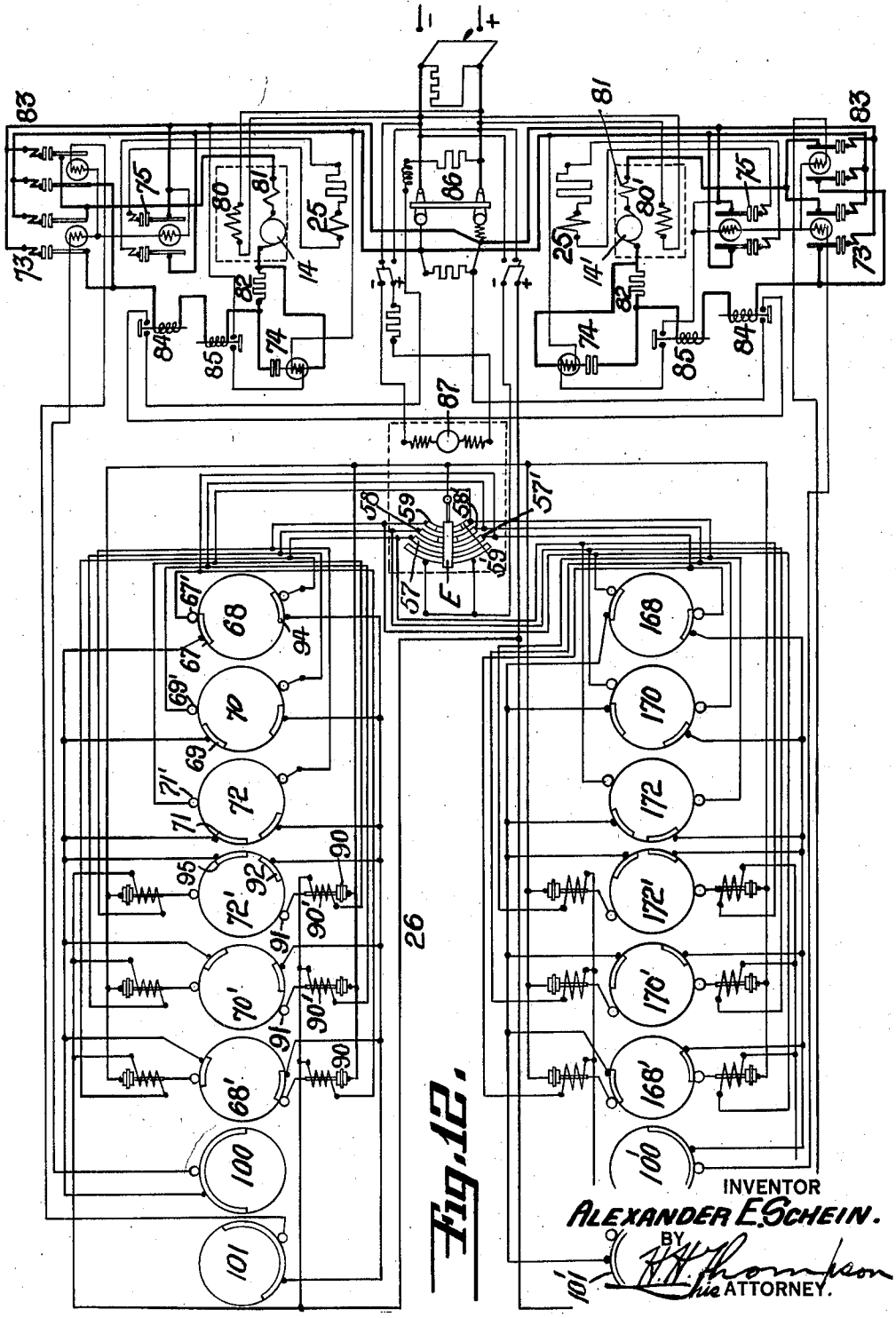

Fig. 12.

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Patented Apr. 14, 1931 1,800,408

UNITED STATES PATENT OFFICE

ALEXANDER E. SCHEIN, OF FLUSHING, NEW YORK, ASSIGNOR, BY MESNE ASSIGNMENTS, TO SPERRY GYROSCOPE COMPANY, INC., OF BROOKLYN, NEW YORK, A CORPORATION OF NEW YORK

ROLL AND PITCH REDUCING DEVICE FOR SHIPS

Application filed January 11, 1928. Serial No. 245,908.

This invention relates to automatic means for minimizing the rolling and pitching of ships by means of extraneous fins or horizontal rudders. Such a means possesses several advantages over other types of stabilizers in that it readily lends itself to the lessening of both pitching and rolling and is especially adapted for fast ships in which the rolling and pitching is most pronounced. My invention relates particularly to a controlling means for the fins which is designed to turn the fins upon the first incipient rolling or pitching motion and which is designed to move fins through an angle roughly proportional to the velocity of roll or pitch and to return the fins to their neutral position as the velocity of roll or pitch approaches zero. In other words, it is the object of the invention to introduce an anti-rolling or stabilizing torque on the ship by the fins of just sufficient amount and properly timed to counteract the rolling effect of the sea and at the same time avoid over-stabilizing which would tend to cause the ship to roll in the other direction and thus waste power and also defeat the object of the apparatus.

Referring to the drawings in which a preferred form of the invention is shown;

Fig. 1 is a side view of a ship provided with my stabilizing fins for preventing both rolling and pitching.

Fig. 2 is a diagrammatic plan view of the same.

Fig. 3 is a diagram showing the comparative action of the rolling forces of the sea and the stabilizing effort of my invention on the ship in an ordinary seaway.

Fig. 4 is a similar diagram of the conditions in a rough sea.

Fig. 5 is an end elevation, partly in section, of one of the control gyroscopes which governs the fins.

Fig. 6 is a detail of the centralizing plungers acting on said gyroscope.

Fig. 7 is a detail of the contacts connected with the opposite side of the gyroscope.

Fig. 8 is a front view of said contacts.

Fig. 9 is a plan view on a smaller scale of the control gyroscope.

Fig. 10 is a section through the ship showing one form of apparatus for controlling and withdrawing one of the stabilizing fins.

Fig. 11 is a detail showing one of the limit switches for the withdrawing means.

Fig. 12 is a wiring diagram of the principal portion of the apparatus.

According to my invention, for counteracting the rolling, I place one or more pair of laterally projecting fins or rudders 1 and 2 amidships, and for counteracting the pitching I place a pair of fins 3 and 4 near the bow and may also, if desired, place a similar pair 5 and 6 near the stern. Preferably separate control means are provided for the anti-rolling fins and the anti-pitching fins, each of which is designed to rotate the fins about substantially athwartship axes in such a direction as to exert an anti-rolling and/or anti-pitching torque on the ship as the case may be, as the ship advances through the water.

Details of one of the anti-rolling fins 1 is shown in Fig. 10 and it is understood that the other fins may be constructed and actuated similarly. Said fin is shown as mounted on a shaft 10 journaled within a water-tight compartment 11 into which the fin is adapted to be withdrawn when not in use. The said compartment is provided at its rear with a water-tight stuffing box 12 and forwardly with a slidable bearing block 13 for the fin. The said fin when extended projects through a slot on the side wall of the ship and is free to be turned with the shaft 10 about an athwartship axis or an axis extending generally in that direction. For adjusting the angular position of said shaft I have shown an electric motor 14 which drives through shaft 15 a pinion 16, said pinion in turn meshing with gear 17 on a long shaft 18 journaled adjacent its ends in brackets 19 and 20 and having a keyway 23′. On said shaft is keyed a second pinion 21 having its hub journalled in a bracket 22 which is slidably mounted on shaft 18 and runway 23. Pinion 21 in turn meshes with a larger gear or gear sector 24 which is keyed to the shaft 10, and also rotatably but non-slidably mounted in bracket 22 as by means of thrust bearing 131. A solenoid brake for the motor is indicated at 25 as acting on the shaft of the motor, the brake being designed

to stop the motor and fin quickly when the circuit is broken. Connected with the motor or fin are suitable limit switches 26. Said switches are shown as mounted in a series upon the shaft 18, the switches being shown in detail in the wiring diagram in Fig. 12 and explained hereinafter.

For withdrawing the fins I may provide within the body of the ship when docking or when the fins are not in use, an additional motor 27 geared through a worm 28 and worm-wheel 29 to a threaded shaft 30. Said shaft is threaded in the hub of a bracket 22 and journaled at one end in bracket 19 and at the other in shaft 10. Shaft 10 is made hollow throughout the greater portion of its length so that when the threaded shaft 30 is revolved the bracket 22 will be drawn rearwardly carrying with it a gear 24, pinion 21, the hollow shaft 10, and the fin 1 itself. A limit switch is shown as provided at each end of the travel of said bracket, each switch being shown as operated by a pin 31 slidably mounted in a housing 32 and normally pressed inwardly by a spring 33 bearing on a collar 34′ (Fig. 11). When, however, the moving bracket strikes the pin it pushes it outwardly and opens the spring contacts 34 and 35 thereby breaking the circuit to the motor 27.

The control of the fins is effected in such a manner as to cause it to oppose the force exerted by the waves on the ship or rolling effort of the waves at each instance by a force substantially equal and opposite. This may be illustrated by reference to the diagrams in Figs. 3 and 4. In these figures the area above the center line to full line A represents the power exerted by the sea on the ship in imparting roll velocity to the ship, the ordinates representing the velocity or kinetic energy of the ship due to the rolling effort of the waves and the abscissæ time in fractions of a second. Dash and dot line B represents the ideal design in which the opposing work done by the stablilizer per unit of time is always in just the right amount to keep the ship's roll down to the desired minimum, say one degree, while the dotted line C represents the velocity of the ship's roll from time to time. The ideal manner then to control the fins would be to cause the fins to exert the force indicated by the ordinates of curve B, or in other words, to cause the fins to do work at the rate indicated by the area below the center line to curve B. On account of the continual and rapid variation in this force, it is only practicable mechanically to approximate this curve, and curve D represents the approximation secured by the present embodiment of the invention in which each fin has three positions on each side of neutral proportionate to the velocity of roll, the several positions being represented at H, J, and N in the two diagrams.

For effecting this purpose I have shown a means responsive to the velocity of roll and a means responsive to the velocity of pitch for controlling the rolling and pitching fins. Each of said means preferably comprises a gyroscope 36—37 having two degrees of freedom; that is the gyroscope is constrained to move about two axes only, its spinning axis and an axis at right angles thereto. Gyro 36 is shown as controlling the anti-rolling fins 1 and 2 and is preferably placed with its horizontal spinning axis 38 normally athwartships and its axis of precession 39 vertical, while the gyro 37 has its horizontal spinning axis 40 normally fore and aft and its precession axis also vertical. The two gyroscopes may thus be identical but are placed differently on the ship, the gyroscope 36 being shown in detail in Figs. 5 to 9.

The rotor 41 of said gyroscope is shown as enclosed within a casing 42 which is mounted for precession about the vertical axis 39 in the fixed frame 43. Precession of the gyroscope about said vertical axis away from its normal athwartship position is yieldingly opposed preferably by a plurality of centralizing springs which apply an increasing centralizing force on the gyroscope as the angle of precession increases. As shown, the centralizing means is in the form of a plurality of opposed plungers 44—45, 44′—45′ and 44″—45″, slidably mounted within threaded housings 50 and pressed inwardly by compression springs 51 so that the inner ends of the uppermost plungers 44, 45 abut against an L-shaped downward extension 46 from the gyro casing (Fig. 6), and also against a fixed stop bracket 49. Said housings 50 are threaded in brackets 52, 52′ and may be adjusted by turning knurled ends 53 and locked in positioned by nuts 54. The compression springs of the topmost plungers are of less effective strength than the other springs. Therefore, only a small centralizing torque is exerted for the initial precession of the gyroscope.

The second pair of plungers 44′—45′ are held somewhat further back in their housings by lugs 47 on said stationary stop bracket 49, while the third pair of plungers are held still further back in their housings by lugs 48 on said bracket 49 (Fig. 6), the springs being of increasing effective strength. Therefore, when the gyroscope first starts to precess, it is opposed only by the weak springs 51 of the uppermost plungers. If the rolling is of sufficient velocity, however, to cause bracket 46 to come in contact with one of plungers 44′ or 45′, a second pair of stiffer springs is brought into action in addition to the first pair, while if a still greater velocity of roll is present the third pair of springs is also brought into action. It is obvious that any desired number of graduated springs may be provided.

On the opposite side of said gyroscope are shown the control contacts for controlling the

motors 14 and 14′ (Figs. 7, 8 and 9). Four super-imposed pairs of stationary contacts 56, 57, 58 and 59 and four cooperating trolleys 60, 61, 62 and 63 mounted on the gyro casing are shown, one pair 56 being a common, the second pair of contacts 57, 57′ being separated by a small insulating space 64 so that the trolley may come in contact with the one or the other of the live segments on initial precession of the gyroscopes. The third pair of contacts 58, 58′ is shown as separated by broader insulated section 65 and the fourth pair 59, 59′ by a still broader insulated section 66. Said contacts and trolleys are shown diagrammatically in the wiring diagram (Fig. 12) as a series of annular segments 56, 57, 58 and 59 and cooperating common brush or arm E represents the trolleys.

Before the fins are withdrawn by motor 27, it is of course necessary that they be aligned with the slots in the ship's hull, said slots usually being placed horizontal. Preferably this is accomplished automatically by interlocking the fin controller (i. e. the gyroscope 42 and the motor 27, so that the fins can only be withdrawn when in the correct position. This is accomplished by providing the gyroscope with a centralizing locking cone 96 mounted for slidable movement on shaft 97 toward and away from the gyroscope. Said cone is normally held retracted by spring 98, but may be pushed into engagement with projection 99 on the gyro case 12 by hand lever 105, thus locking and centralizing the gyroscope, which, of course, also centralizes the fins. As the cone is moved forward it closes contact 106 in circuit with motor 27 (Figs. 9 and 10) to withdraw the fins.

The wiring diagram shows both motors 14 and 14′, the motors being shown as of the constantly excited field type, said fields being shown at 80 and 80′. A small compensating series winding 81 is also shown in series with the armature. Each motor is controlled from a starting relay 74 so that the motor is first started up slowing through starting resistance 82 and then given a second speed when relay 74 closes to short circuit said resistance. Each motor is also adapted to be driven in either direction, the control in one direction being effected by relays 73 and in the reverse direction by relays 83. Relays 84 and 85 represent any suitable form of circuit breakers in series with the motor armature, while the main circuit breaking switch in the main line is shown at 86. Relays 75 control the aforesaid solenoid brake 25. The motor driving the gyro rotor is represented at 87. The control of both motors 14, 14′ may be identical as shown, except, of course, the connections are such that the motors are actuated to turn the fins oppositely to counteract the roll. The aforesaid contacts on the gyroscope control the motors 14 and 14′ through the system of relays just described in combination with the series of limit switches 26 controlled from each motor or fin, which will now be described in detail. There are eight of said switches shown for each motor, all of said switches having two contact sections, one switch for each step position of the fin in each direction and two commons 100 and 101, and one section being live when the gyro is precessed counter-clockwise and the other when the gyro is precessed oppositely. Thus contact 67 of switch 68 and brush 67′ cooperates with contact 57′ on the gyroscope, contact 69 of switch 70 with gyro contact 58′, contact 71 of switch 72 with gyro contact 59′. The conducting segments of each switch are of limited length and positioned so as to interrupt the current supply when the fin is turned through a predetermined angle. Thus, if the gyro starts to precess in a counter-clockwise direction (Fig. 12) contact of arm E with strip 57′ will complete a circuit through brush 67′ conducting segment 67 of switch 68. This starts the motor 14 in the proper direction through relay 73 and thus turns the fin and sector 68 clockwise until the segment 67 moves out from under the brush 67′. This breaks the circuit with the motor through relay 73 and 74 so that the fin is immediately brought to rest under the action of the solenoid brake 25 through relay 75, provided, however, that in the meantime contact has not been made between arm E and one of the next pair of contacts 58′. If this has been done, however, a new circuit is established through the segment 69 of switch 70 so that the current is not interrupted until this segment passes from under the cooperating brush 69′. Even then the current is not interrupted if in the meantime the gyro has precessed further to close the last contact 59′ to complete a circuit through switch 72. In such an event the fin is moved through its largest angle to exert its maximum stabilizing effort. At this time the ship will be at its maximum velocity of roll when it is passing through its vertical position. As the velocity of roll decreases as the ship rolls to the other side, the gyro will start to move back under the influence of the centralizing springs 51, etc.

The control of the reverse movement of the fin is effected from contact switches 72′—70′ and 68′. Said switches are similar to the forward switches of like numerals, except that in this instance the circuit through the brushes or trolleys bearing thereon is open when current is flowing through the companion switches. This is effected by contacts 90 in series with the brushes 91 and which are biased in a closed position by springs (not shown) but which are open when current is flowing through the windings 90′ thereof, said windings being in circuit with

corresponding switch 72, 70 or 68 and gyro contact 59, 58 and 57. When, therefore, the contact with switch 59′ is broken with the gyro the circuit through first solenoid 90′ is broken and the switch 90 closes to complete a circuit through brush 91, and contact segment 92 to the reversing relays 83, thus starting the motor 14 in the opposite direction. The motor, however, will stop when the contact 92 moves from under brush 91 unless in the meantime the ship has further lessened its rolling velocity so that gyro contact 58′ has been broken. In such an event the aforesaid cycle is repeated with respect to switch 70′ and so on with contact 57′ and switch 68′. When the ship comes to rest, therefore, the fin is in its horizontal position. As soon as the ship starts to roll in the other direction, the arm E moves over the opposing contacts 57, 58, 59 as above described completing equivalent circuits through the lower contacts 94 of the rotary switches 68, 70 and 72, and on return movement similar circuits are completed through the upper contacts 95 of switches 72′ 70, 68′. While the above sequence is being carried out, it is understood that the same cycle is being repeated with respect to the series of contacts 168, 170, 172, 172′, 170′ and 168′ with respect to the motor 14′ on the opposite side to move fin 2 oppositely.

It will also be understood that the control of the anti-pitching fins may be identical in principal for control gyro 37. In this case, however, the bow fins 3 and 4 are controlled from a single motor 80 with the shaft 81 thereof extending across the bow while the stern fins 5 and 6 are also controlled from the single motor 80′ with the shaft 81′ extending across the stern, each pair of fins being turned in the same direction but with the two pair being oppositely turned for best anti-pitching action.

Two typical examples of the operation of my device are given in Figs. 3 and 4 described above. As stated, the broken line D or D′ represents the actual anti-rolling effort of the fins, or in other words, represents the angular position of the fins with respect to horizontal. In Fig. 3, representing moderate sea conditions, the ship is assumed to have just reversed its roll and is starting to roll in the other direction at point F. A moment later at G the gyro has made its first contact with contact 57′ and the fin starts to move to its first position, arriving at this position at H where contact 67 has moved out from under brush 67′. Under the conditions shown in this figure the rolling velocity has not carried the gyro onto the contact 58′ so that the fin remains in that position until point I is reached where the gyro is assumed to make its second contact with 58′. The fin then is moved to the next position at J where contact between 69 and 69′ is broken. Again the gyro has not moved over into contact with 59′ so that the fin remains in that position. At point 3 near midpoint K the contacts 59 are assumed to close momentarily, but are opened again at −3 before the time lag of the system has been overcome and the fin moved materially. From K to L the ship's rolling velocity starts to decrease slowly but its velocity is sufficient to maintain the gyro on contact 58′ until point L is reached. At this point the gyro breaks its second contact with 58′, thereby breaking the circuit through second solenoid 90′ and completing the circuit through the contacts of switch 70′ to reverse the motor. This brings the fin back to its horizontal position at M, as the contacts 70′ and 68′ are designed to operate successively without pause, the ship's angular velocity reaching zero a moment later.

More severe rolling conditions are shown in Fig. 4. Here the gyro again makes contact with 57′ at G, but unlike the case in Fig. 3 the gyro makes it second contact with 58′ and its third contact with 59 before contact 67 is turned from under brush 67′ and before contact 69 is turned from under brush 69′ respectively. The fin, therefore, moves uniformly to point N. At this point it is assumed that the stabilizing force of the fin has become great enough to reduce the velocity of roll below the maximum for which the apparatus is set. This causes contact of the gyro with 59′ to break thereby throwing in the reverse relay until point O is reached where contact between contact 71′ and 90 is broken. The ship is then assumed to again gain velocity, which again causes the gyro to contact with contact 59′ and move the fin to its extreme position at N′. Again the velocity of roll is decreased, the fin being moved back one step to O′ where the velocity remains substantially constant until the point P is reached, where the velocity of roll steadily decreases and the fin is moved back through its second and first positions to its horizontal position at M. By this means it will be seen that an approximation has been reached to the theoretical work required for the stabilizer, since D and D′ closely approximate lines B and B′.

In accordance with the provisions of the patent statutes, I have herein described the principle and operation of my invention, together with the apparatus which I now consider to represent the best embodiment thereof, but I desire to have it understood that the apparatus shown is only illustrative and that the invention can be carried out by other means. Also, while it is designed to use the various features and elements in the combination and relations described, some of these may be altered and others omitted without interfering with the more general results

outlined, and the invention extends to such use.

Having described my invention, what I claim and desire to secure by Letters Patent is:

1. In a ship stabilizer, a rotatable fin adapted to project into the water, a constrained gyroscope having two degrees of freedom, and successive means brought into action by precession of said gyroscope for turning the fin through a variable angle proportionate to the extent of precession of the gyroscope.

2. A ship stabilizer for reducing rolling comprising a pair of normally horizontal rudders adapted to project substantially amidships, motive means for turning said rudders in opposite directions about athwartships axes, and means responsive to the velocity of rolling for actuating said motive means to turn the rudders an amount dependent upon the velocity of roll, comprising a control gyroscope having a plurality of contacts adapted to be completed successively as the gyroscope precesses, and a plurality of corresponding limit contacts connected with said rudders.

3. An anti-rolling and pitching mechanism for ships including a control gyroscope mounted for precession on roll of the ship, a second control gyroscope mounted for precession on pitch of the ship, anti-rolling fins, means governed by the first-named gyroscope for turning said fins an amount proportional to the extent of precession of said first gyroscope, anti-pitching fins and means governed by the second-named gyroscope for turning said last named fins an amount proportional to the extent of precession of said second mentioned gyroscope.

4. In a ship stabilizer, a pair of fins rotatably mounted on the ship's hull and adapted to project laterally into the water, the hull having slots through which said fins may be withdrawn, a gyroscope for governing the angular position of the fins, means for withdrawing the fins, and means for locking the gyroscope in a position to align the fins with said slots when said withdrawing means is actuated.

5. In a ship stabilizer, a pair of fins rotatably mounted on the ship's hull and adapted to project laterally into the water, the hull having slots through which said fins may be withdrawn, a gyroscope for governing the angular position of the fins, means for withdrawing the fins, means for locking the gyroscope in a position to align the fins with said slots, and means brought into action by said locking means for actuating said withdrawing means.

6. An anti-rolling and pitching device for ships, including a pair of anti-pitching fins forward, a pair of anti-pitching fins aft, a constrained gyroscope for turning said pairs oppositely to oppose pitching an amount proportionate to the velocity of pitch, a pair of anti-rolling fins amidships, and a constrained gyroscope for turning said last-named fins oppositely to oppose rolling an amount proportionate to the velocity of roll.

7. A ship stabilizer for reducing rolling comprising a pair of normally horizontal fins adapted to project substantially amidships, motive means for turning said fins in opposite directions about athwartships axes, and means responsive to the velocity of rolling for actuating said motive means to turn the fins an amount dependent upon the velocity of roll, comprising a control gyroscope having a plurality of contacts adapted to be completed successively as the gyroscope precesses, a plurality of corresponding limit contacts connected with said fins, and a brake for locking the fins in position when said motive means stops.

In testimony whereof I have affixed my signature.

ALEXANDER E. SCHEIN.