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J. I. THORNYCROFT.

APPARATUS FOR LESSENING THE ROLLING OF VESSELS.

No. 507,944. Patented Oct. 31, 1893.

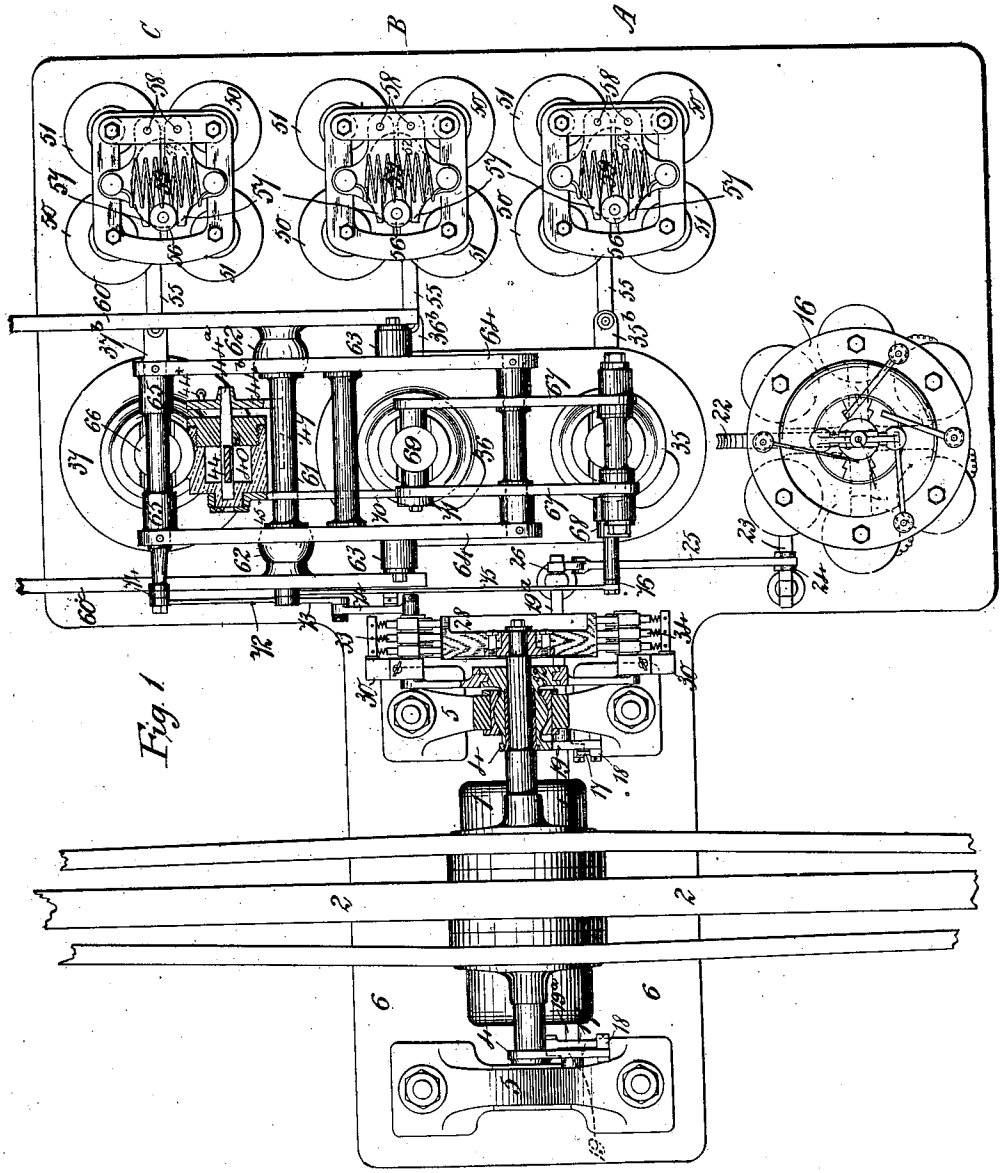

Fig. 1.

Witnesses.
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(No Model.) 9 Sheets—Sheet 2.

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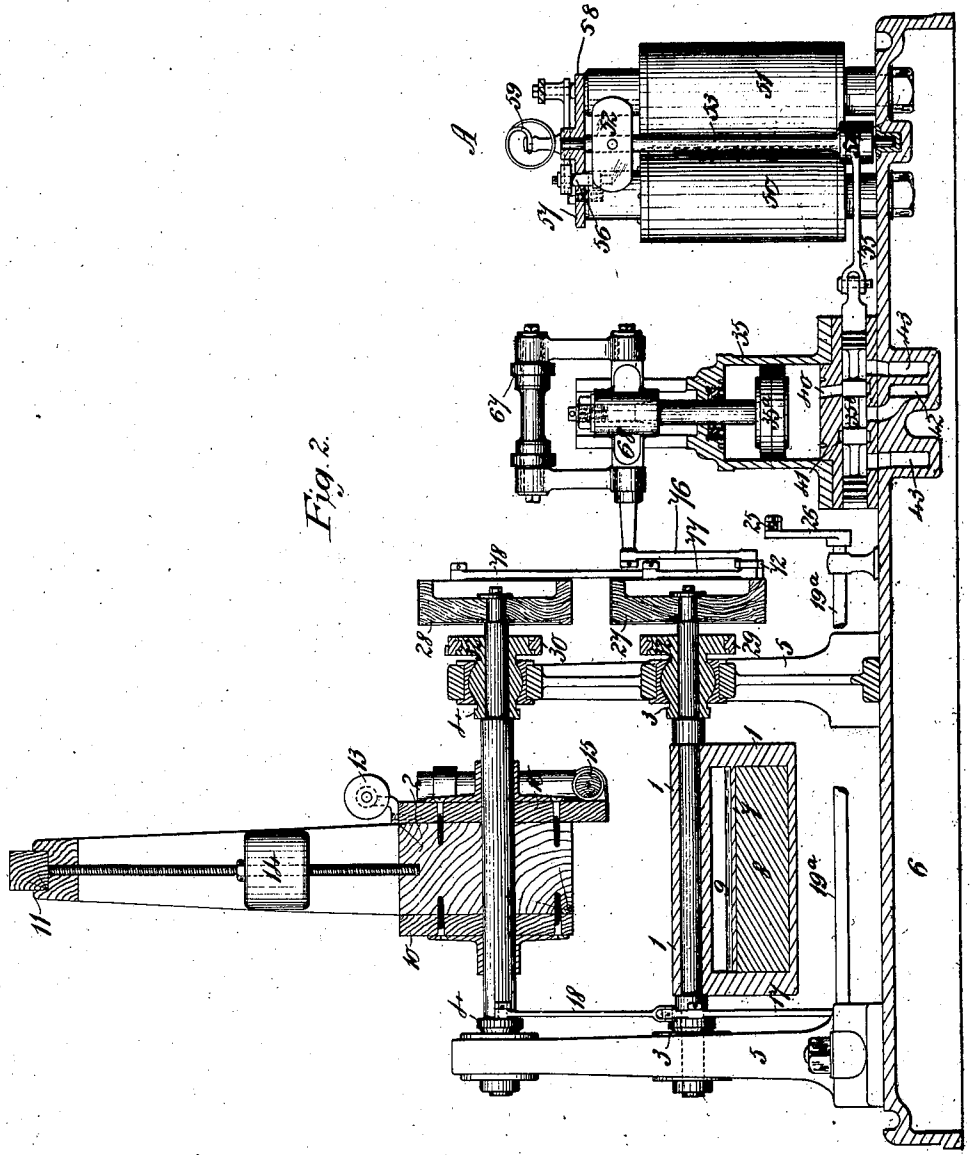
APPARATUS FOR LESSENING THE ROLLING OF VESSELS.

No. 507,944. Patented Oct. 31, 1893.

Fig. 2.



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(No Model.) 9 Sheets—Sheet 3.

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APPARATUS FOR LESSENING THE ROLLING OF VESSELS.

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Fig. 4

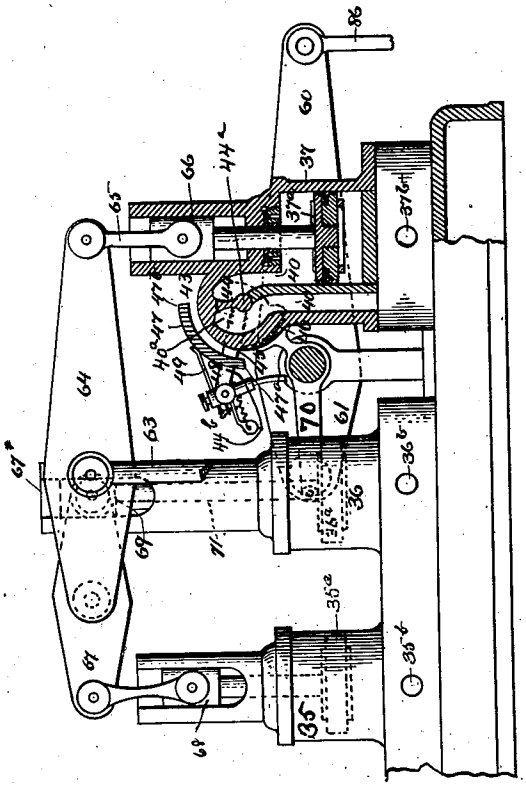
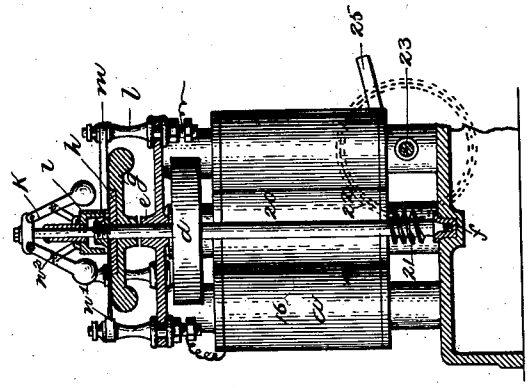


Fig. 3



Witnesses
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(No Model.) 9 Sheets—Sheet 4.

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APPARATUS FOR LESSENING THE ROLLING OF VESSELS.

No. 507,944. Patented Oct. 31, 1893.

Fig. 5.

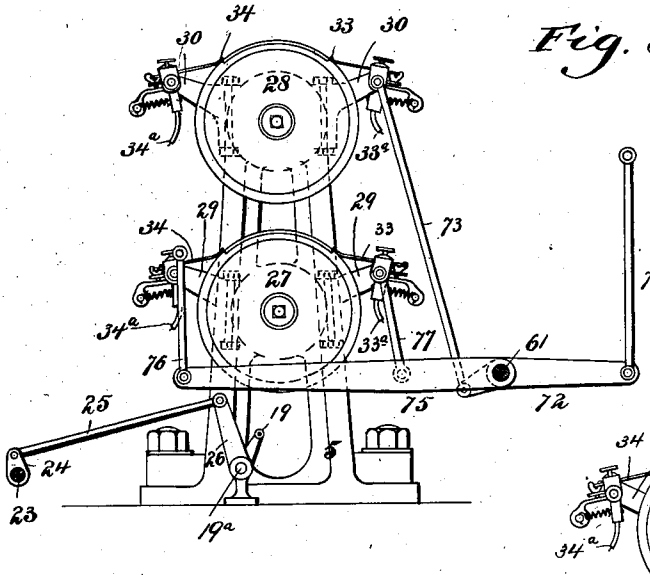
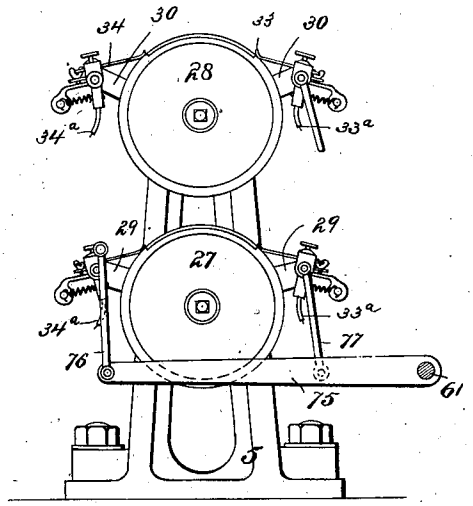


Fig. 7.



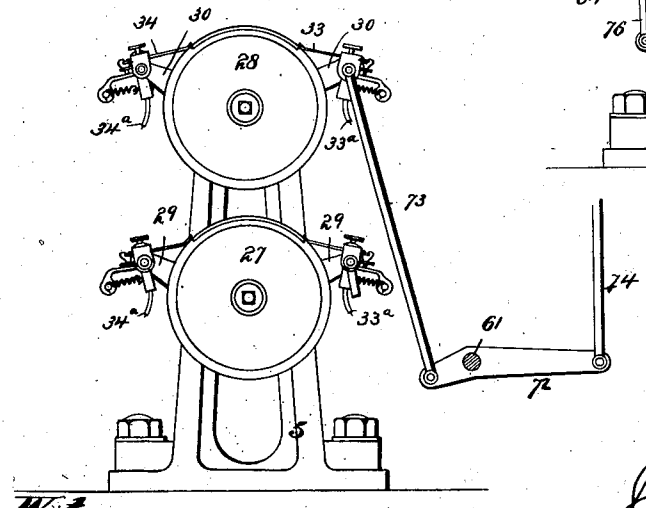


Fig. 6.

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(No Model.) 9 Sheets—Sheet 5.

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APPARATUS FOR LESSENING THE ROLLING OF VESSELS.

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Fig. 8

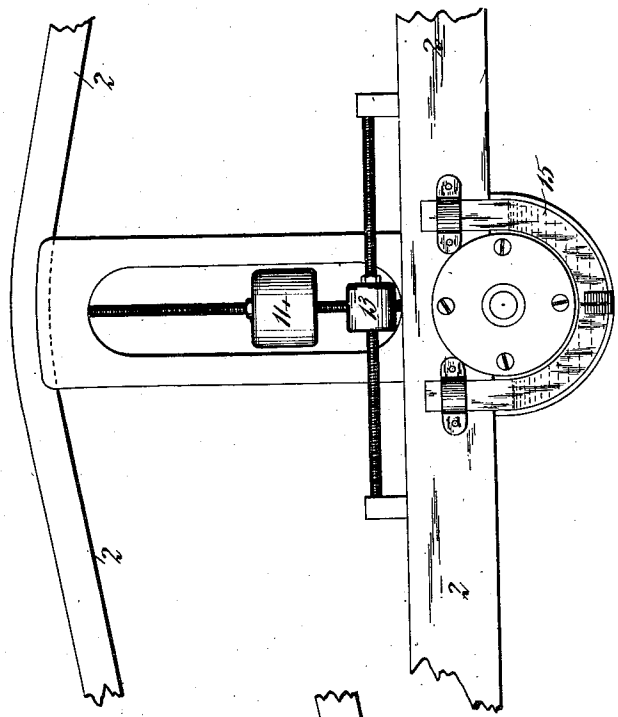
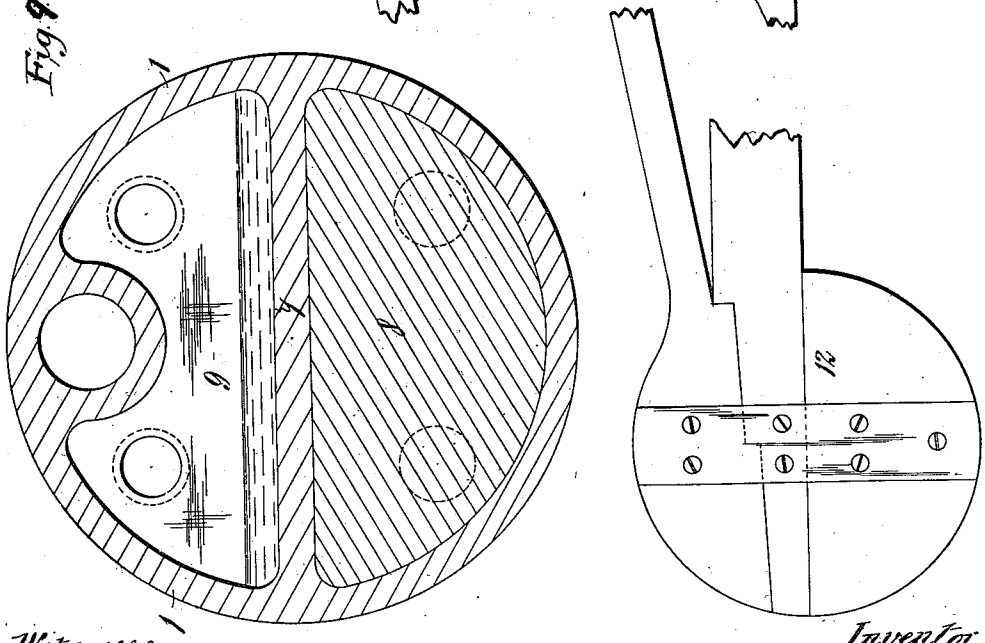


Fig. 9



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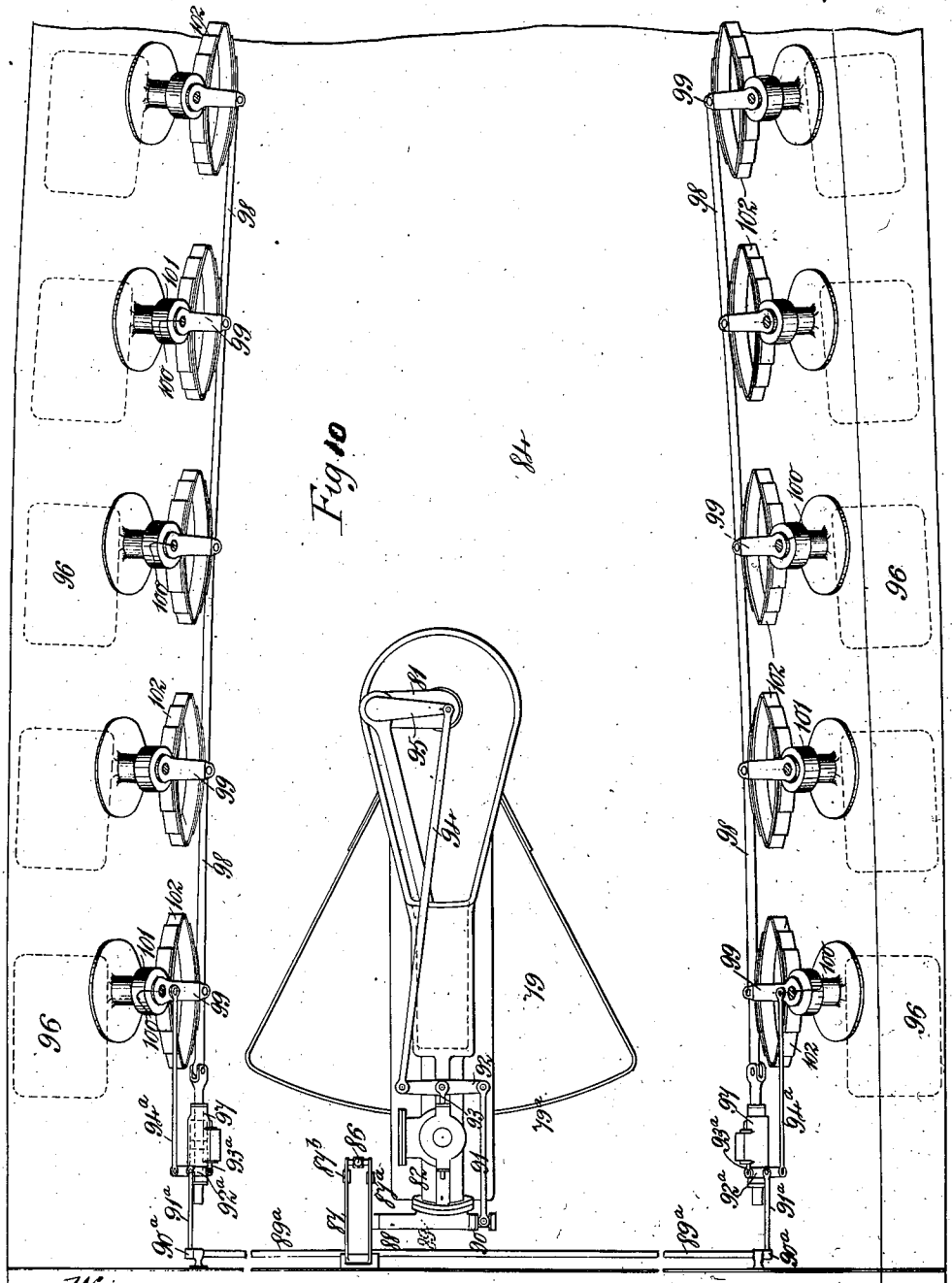

Fig. 10.

Witnesses.
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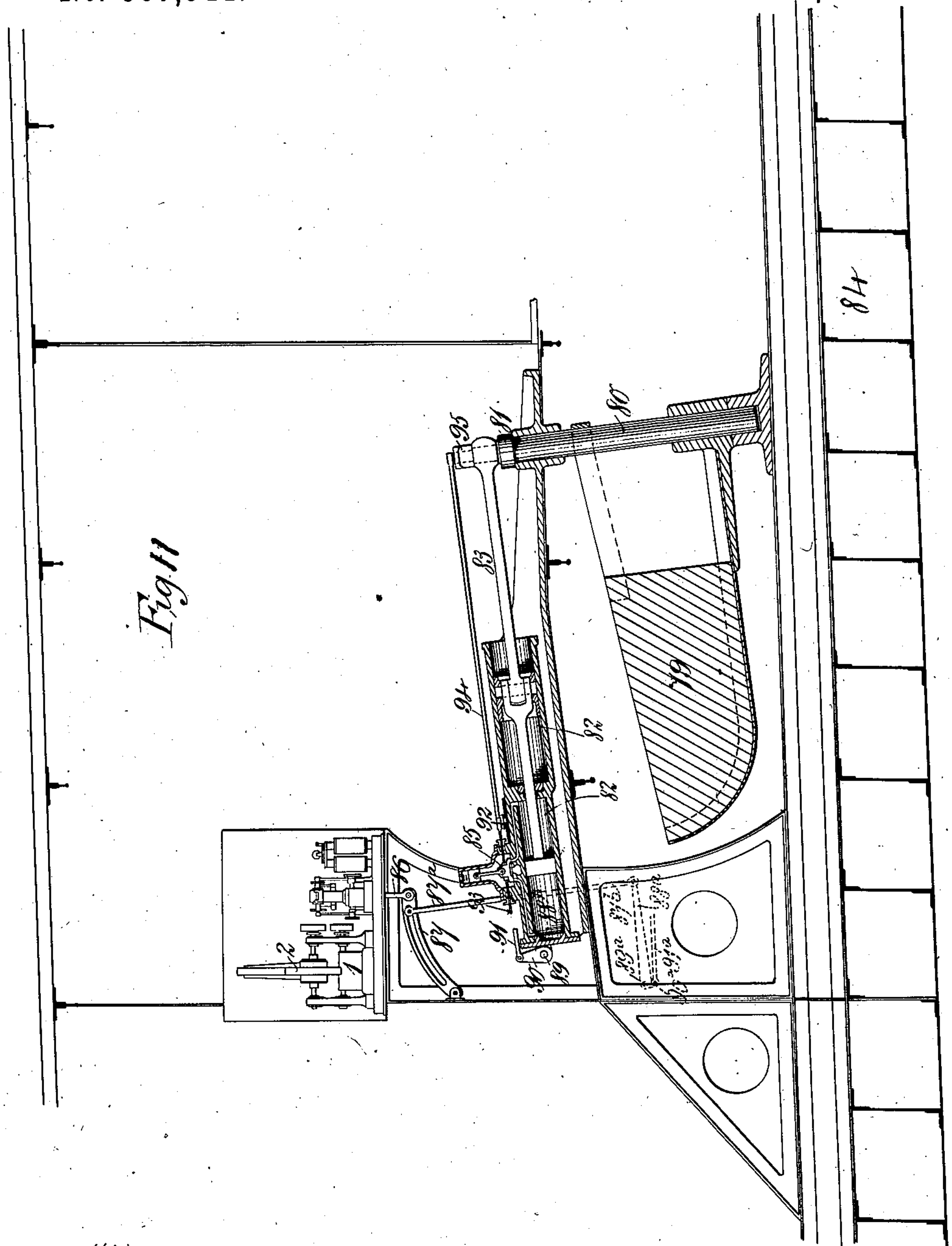

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Inventor:

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(No Model.) 9 Sheets—Sheet 8.

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APPARATUS FOR LESSENING THE ROLLING OF VESSELS.

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Fig 12.

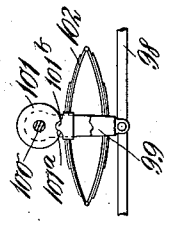
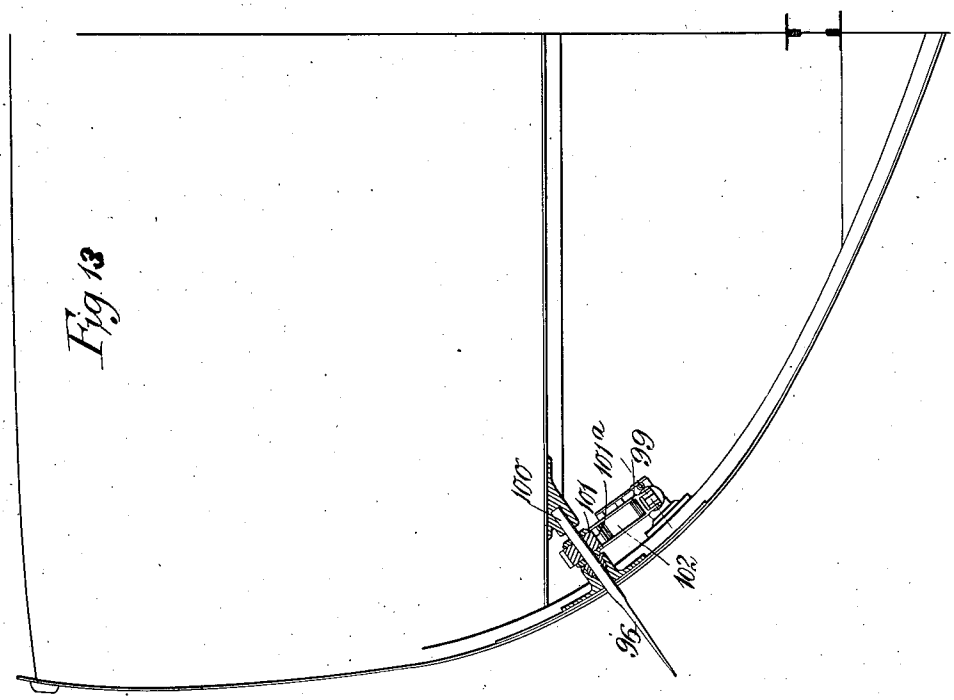


Fig 13.



Witnesses.
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Theodore Supplee

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John Isaac Thornycroft

(No Model.) 9 Sheets—Sheet 9.

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APPARATUS FOR LESSENING THE ROLLING OF VESSELS.

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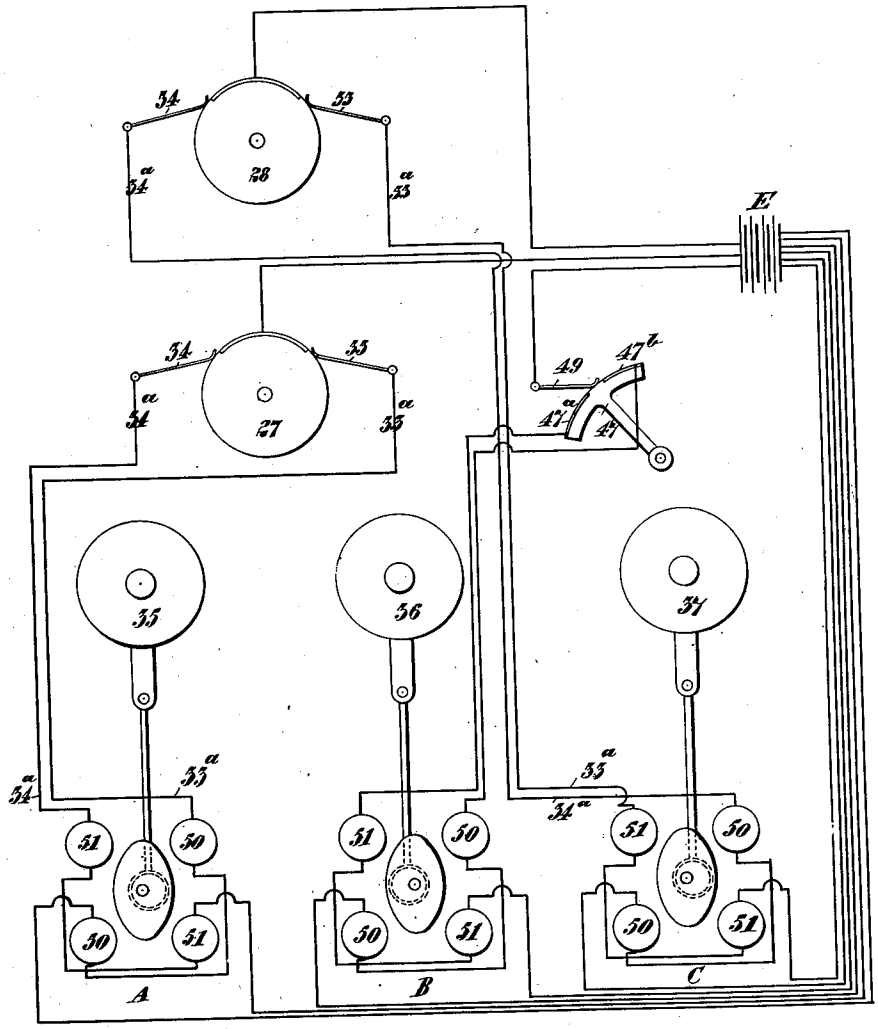
Fig. 14.



Witnesses
Joel A Blackwood
Albert B. Blackwood

Inventor;
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by W. Woodville
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UNITED STATES PATENT OFFICE.

JOHN ISAAC THORNYCROFT, OF LONDON, ENGLAND.

APPARATUS FOR LESSENING THE ROLLING OF VESSELS.

SPECIFICATION forming part of Letters Patent No. 507,944, dated October 31, 1893.

Application filed November 26, 1889. Serial No. 331,712. (No model.) Patented in England May 20, 1889, No. 8,340.

To all whom it may concern:

Be it known that I, JOHN ISAAC THORNYCROFT, a subject of the Queen of Great Britain and Ireland, residing at Chiswick, in the county of Middlesex, England, have invented an Apparatus for Lessening the Rolling of Vessels, (for which I have obtained Letters Patent in Great Britain, No. 8,340, dated May 20, 1889), of which the following is a specification.

My invention has reference to a method of preventing or lessening rolling of a vessel at sea by, first, balancing the turning moment or forces tending to make the vessel place her masts at right angles to a wave; second, maintaining the vessel's stability; and third, offering resistance to any rolling motion she may from any cause attain.

The apparatus I employ to perform the three distinct duties above indicated includes controlling gear capable of measuring the necessities of each instant and governing other apparatus providing forces adequate to meet them. The controlling apparatus depends first on a pendulum hereinafter called the short pendulum having a short period compared with the natural period of oscillation of the vessel to be steadied, or of the waves on which the vessel floats and if the vessel is inclined, the control of the apparatus by this pendulum alone will greatly reduce stability. A second pendulum (hereinafter called the long pendulum) is adapted to join in control with the short pendulum and more or less balance its tendency to reduce stability when the vessel is inclined. The long pendulum must have a long period compared with the natural period of the vessel, or of the waves acting on the vessel, and should therefore have a large moment of inertia, but be supported as near to its center of gravity as will give it necessary stability, it being required to give as far as possible an absence of rotation about some axis about which any rotation of the vessel may be measured. The two pendulums are used to exercise a joint control, the one modifying the action of the other. There is also double duty obtained from the long period pendulum, hereinafter included in the expression the long pendulum. The first duty of the long pendulum is under certain circumstances before described, to counteract one effect produced by the short period pendulum and restore to the vessel the stability the short pendulum takes away. The short pendulum is to balance the tendency of a vessel to set her masts at right angles to the surface of what is called the equivalent wave slope on which she floats or to the suface of still water to which she is inclined. Thus the short pendulum would prevent the vessel righting from an inclined position in still water; the long pendulum however will give the vessel power to right again by balancing more or less the effect of the short pendulum when the vessel is inclined. A further duty of the long pendulum is to give control to apparatus which causes resistance to rolling motion independent of the vessel's position, or the action of waves, and this control will modify the action of the short pendulum and the other action of the long pendulum which gives stability.

The pendulums I suspend on bearings having very small friction so that they shall not be disturbed by rolling motion of the vessel, and to enable them to exercise control, also without influencing their position, I may, as hereinafter described pass a current of fluid through them in such a manner as to cause no reaction tending to disturbance. I prefer however to use an electric current through contacts having small friction. By this electric current electro magnets can be made to work valves controlling pistons connected to the contacts so as to follow the motion of the pendulums and thereby complete the control apparatus which may have the various elements of control capable of being so combined as to meet the varying necessities of a vessel at sea; that is, the period of oscillation of the vessel may be varied, the stability at the same time being altered, or the power to resist rolling motion only changed.

The apparatus for providing force to resist the rolling effort of waves, or resistance to retard motion, may consist either of a heavy mass made to move in the vessel so as to balance the forces; or of movable fins or blades exposed to the water moving past the vessel and provided with suitable means to adjust the angle of their surface at each instant.

As will be evident apparatus to operate on the principle of my invention as above set forth, may be constructed in various forms.

Referring to the accompanying drawings, Figure 1, is a plan view, with parts broken away, of a controlling apparatus for the steadying mechanism. Fig. 2, is a vertical section thereof. Fig. 3, is a sectional elevation of the controlling electric motor. Fig. 4, is a sectional elevation of a portion of the controlling apparatus taken in a plane at right angles to the plane of Fig. 2. Figs. 5, 6, and 7, are respectively end views of the commutators controlled by the pendulums, showing also mechanisms for operating the two sets of brushes and for oscillating the pendulum bearings. Fig. 8, is a detail elevation of the long pendulum with parts broken away. Fig. 9, is a cross sectional view of the short pendulum. Fig. 10, is a diagrammatical view showing two arrangements of steadying appliances applied to a navigable vessel. Fig. 11, is a vertical sectional view of a part of a vessel showing a steadying apparatus in section and the controlling apparatus in elevation. Fig. 12, is a detail view of the spring connection with a retarding or steadying blade. Fig. 13, shows one side of a vessel in section showing a steadying blade and part of its controlling mechanism. Fig. 14, is a diagrammatical view illustrating the controlling circuits.

Referring to the drawings, 1 is the short pendulum, and 2 the long pendulum; they are fixed upon spindles mounted to turn in oscillating bearings 3, and 4 respectively, that are supported in standards 5 carried by a base plate 6. The short pendulum should be located with its axis of oscillation coincident with, or near to and practically in the same direction as the axis about which the ship rolls. The short pendulum is formed as a heavy cylinder (normally horizontal), long in proportion to its diameter, and mounted so as to have an axis of oscillation parallel to the axis of the cylinder that constitutes the pendulum. It may conveniently be constructed as illustrated in Figs. 2 and 9. In this arrangement it is hollow, with a longitudinal diaphragm 7, the space below which is filled with suitable substance such as heavy metal 8 (such as, for example, lead). The space above the diaphragm is partly filled with liquid 9 such as mercury which will have the effect of obviating excessive vibration of the pendulum. The long pendulum 2 is supported with its axis of oscillation parallel to and above that of the short pendulum. In the drawings the long pendulum is shown as being a built up beam comprising two lower longitudinal members and an upper or tension member, the ends being provided with massive parts or weights 12. The center of gravity of this long pendulum should be (speaking comparatively with reference to the length of the pendulum) only a small distance below the axis of oscillation.

13 is an adjustable weight for the purpose of accurately balancing the pendulum, and 14 is an adjustable weight for varying the position of the center of gravity of the pendulum according to requirement.

15 is a bent tube secured to the long pendulum and partly filled with mercury with the object of obviating excessive vibration of the pendulum.

16 is an electric motor adapted to oscillate the bearings 3 and 4 of the pendulums for the purpose hereinbefore mentioned. The motor 16 may be of any suitable construction.

Oscillating movement is imparted by the motor to the bearings as follows:—Two sets of rods each comprising two rods 17 and 18 that are jointed together and to arms projecting from the respective bearings as shown, are operated by crank arms 19 on a rock shaft 19^a which is driven from the driving shaft 20 through the intervention of a worm 21, worm wheel 22, shaft 23, crank 24, connecting rod 25, and lever arm 26. The crank arms 19 are arranged at opposite sides of the axis of the shaft 19^a so that when the one set of rods 17 and 18 is raised, the other set will be lowered, and the two bearings of the short pendulum 1, as also those of the long pendulum 2, will thus be caused to oscillate in opposite directions, so that the friction of one shall balance that of the other, thus giving each pendulum great freedom of turning.

27 and 28 are commutators secured on the spindles carrying the pendulums 1 and 2 respectively. These commutators are provided with brush holders 29 and 30 respectively; each of which is mounted to turn on an extension 32 of the adjacent oscillating bearings 3 or 4. Each commutator comprises a metal plate supported on insulating material. Each brush holder is fitted with two sets of brushes 33 and 34; these normally rest upon the insulating portion of the commutator; and each set of brushes is connected to an independent set of electro magnets in a valve operating device hereinafter described.

35, 36, and 37 are three motor cylinders, fitted with double acting pistons 35^a, 36^a, and 37^a respectively. These cylinders are also provided with piston-distributing valves 35^b, 36^b, and 37^b respectively for motive fluid (for example, water under pressure). Each valve works in a valve chamber and controls ports and passages 40 and 41, that communicate with the respective ends of the corresponding cylinder; also each of the valves controls other ports communicating with the inlet and outlet passages 42 and 43 respectively of its cylinder. The passage 40 of the cylinder 37 is enlarged at 40^a to form a chamber within which is arranged a piston 44 that is or may be moved by the fluid on its way to or from the upper part of the cylinder. In the example illustrated the movement of this piston is one of partial rotation. The piston 44 is connected to a commutator 47 by means of a spindle 44^a and lever 44^b (Fig. 4).

54 is an external lever that is provided with segmental teeth 46.

48 is a brush holder carried by the lever 45 and provided with a set of brushes 49 adapted to bear normally upon an insulating portion of the commutator. The chamber 40^a is formed with channels 40^b that serve as by-passages to vary the action of the fluid on the piston 44 in order to admit of alterations in the time occupied by this piston in returning to the mid-position (shown in Fig. 4). The piston does not accurately fit the chamber 40^a at its sides. Consequently fluid is permitted to pass between the two without actuating the piston if such fluid be moving slowly.

A, B, and C are the devices for operating the valves 35^b, 36^b, 37^b respectively. Each of these devices comprises two pairs of electro magnets 50 and 51 and an armature 52. This armature is fixed upon a spindle 53 formed with an eccentric at 54 to which is fitted one end of an eccentric rod 55, the other end of which is jointed to one of the distributing valves. The pairs of electro magnets 50 and 51 of the magnetic device A are connected by conductors 33^a, 34^a to the sets of brushes 33 and 34 respectively of the commutator 27. The magnets of the electro magnetic device C are similarly connected to the sets of brushes of the commutator 28. The electro magnets of each device A and C are also connected to one pole of an electric generator, the other pole of which is connected to the insulated metal plate on each commutator 27, 28. The pairs of magnets for operating the distributing valve 36^b, are connected to insulated metal plates 47^a 47^b of the commutator 47, and also to one pole of an electric generator E, the other pole of which is connected to the set of commutator brushes 49. Each armature 52 is provided with a pin or roller 56 that is acted upon at opposite sides by levers 57 pivoted at 58 and held together by a spring 59. By this arrangement the armature and connected distributing valve will be returned to their normal positions, (shown in Fig. 2) after they have been operated by one of the pairs of electro magnets 50 or 51, and the circuit of these magnets has been broken.

60, 60 are levers which directly govern the steadying apparatus hereinafter described. They are freely mounted upon a shaft 61 carried in bearings 62, and are connected by links 63 to another pair of levers 64. The levers 64 are connected at one end by links 65 to a cross head 66 carried by the rod of piston 37^a, and at the other end are jointed to another pair of levers 67. The levers 67 are connected at one end by links to cross head 68 and at the other end are directly attached to crosshead 69. These crossheads 68 and 69 are secured to the rods of pistons 35^a and 36^a respectively.

70 is a lever mounted on the shaft 61; one of its arms is a toothed segment that gears with the rack 46 on the lever 45; the other arm 70 is connected by a link 71 to the cross head 69.

72 is a lever turning freely on the shaft 61. One arm of this lever is connected to the brush holder 30 by a link 73 its other arm being connected by a link 74 to one end of one of the pair of levers 64 which end has a vertical motion nearly similar to the crosshead 66.

75 is another lever one end of which is carried by the shaft 61 in such a manner that it can turn freely thereon. The other end of this lever 75 is connected by a link 76 to the crosshead 68. A link 77 attached to an intermediate point of the lever 75 gives motion to the brush-holder 29. The motion given to the brush holders 29 and 30 by the levers 72 and 75 respectively is for the purpose of moving over the respective commutators, the sets of brushes carried by the said holders.

The steadying apparatus, according to one arrangement, comprises a heavy movable weight 79 secured to a shaft 80. This shaft may advantageously be inclined as shown, and is provided with a crank arm 81.

82 is a hydraulic motor, the piston of which is connected by a rod 83 to the crank 81 for the purpose of turning the weight 79 from its central and normal position (shown in Figs. 10 and 11) to one or other side of the center line of the navigable vessel 84, as may be necessary to balance a turning moment or force exerted on the vessel by waves; or to prevent or lessen rolling of such vessel.

85 is the distributing valve of the motor; it is operated and controlled from the levers 60 of the controlling apparatus by means of a rod 86, pivoted slotted link 87, rod 87^a, crank arm 88, shaft 89, crank arm 90, rod 91, lever 92, and valve rod 93. The lever 92 is also connected by a link 94 to a crank arm 95 that is secured to the outer end of the crank arm 81. The crank arm 95 is of greater length than the crank arm 81. The rod 86 may be directly connected to the valve operating lever 88, but by using a pivoted slotted link 87, and a rod 87^a adjustably connected thereto, the extent to which the valve of the motor 82 is moved can be varied as desired. Thus the steadying apparatus may be put to work to its full extent, or to any fraction of it; or it may have its efforts entirely suspended should the controlling apparatus from any cause, cease to work properly.

For a vessel of say two hundred and fifty to three hundred tons displacement, a movable weight 79 of about twelve tons may be used, and be so arranged that its center of gravity can move through about three feet on either side of the central vertical plane of the vessel. It is however advantageous to allow the weight to make a complete revolution if necessary, so as to avoid any danger that might arise from striking an object if its path were limited in extent. The inclination of the shaft 80 as shown, enables the power necessary to work the weight to be reduced; also

it imparts to the weight a tendency to maintain a central position in relation to the ship, instead of to give the vessel a list one way or the other, should the hydraulic or other gear used to operate the weight, fail from any cause. In lieu of, or in addition to the internal movable weight 79, the vessel may be provided with a series of movable blades 96 arranged at each side of, and external to the vessel. In order that these movable blades may oppose as little resistance to progress as possible, the area of their surfaces should be large enough to control the vessel's rolling, without being placed at a large angle to the direction of motion of the passing water, and as they would usually be employed when the vessel was moving ahead, the axis about which the surface of each blade would turn might be placed near the forward end or edge as shown so as to be controlled with as little force as possible. The blades in the example shown, are capable of being turned in either direction, each through an angle of about fifteen degrees from its normal position. The blades in each set are simultaneously operated by the piston of a hydraulic motor 97 through a connecting rod 98, and levers 99, of which there is one for each blade. To allow the blades to turn independently of the motor, when a certain turning moment is exceeded, the spindle 100 of each blade has fixed thereto a cam or block 101, in the under side of which is formed a recess 101^a (Figs. 12 and 13). Into each recess is forced a tongue 101^b carried by a strong spring 102 which is supported in any convenient manner. Each spring is guided by and connected to one of the levers 99 which may be made fork shape to embrace the spring between its two portions as shown. Each lever 99 for turning or operating a blade through the corresponding spring, tongue, and cam has one of its ends fitted to turn freely upon the end of the corresponding blade spindle 100. This arrangement will permit the blades, if displaced by a violent wave, to move edgewise to the current to obviate bending or breakage. Rapid movement of the vessel astern also, would cause displacement of the blades. Two diametrically arranged recesses may be formed in each cam 101, one corresponding to motion ahead, and one to motion astern. If the blades are displaced by a wave, then, when the wave is gone, the motion of the vessel through the water will bring the blades back nearly into the required position again, and motion of the levers 99 will bring the tongues 101^b sufficiently near to the recesses 101^a to cause the tongues to slide into the recesses. The distributing valve of each motor 97 is operated from a rod 87^b (Figs. 10 and 11) by a lever arm 88^a, shaft 89^a, crank arm 90^a, rod 91^a, lever 92^a and valve rod 93^a in a similar manner to the valve of the motor 82. The lever 92^a of each motor 97 is connected to one of the levers 99 by a rod 94^a. The motive fluid for working the pistons in the various cylinders or motors herein referred to may be supplied by any suitable apparatus such as a pump or compressor.

The operation of the apparatus is as follows:—When the vessel to which the apparatus is applied is subjected to a turning moment or force tending to place the masts of the vessel at right angles to a wave, the short pendulum 1, owing to its period of oscillation being (as hereinbefore mentioned) short compared with that of the vessel or of the waves on which the vessel floats, will oscillate quicker than the vessel, and will cause the commutator 27 to turn, and to complete the circuit of one or other of the pairs of magnets 50 or 51 of the device A. The direction in which the pendulum turns will determine which magnet will have its circuit closed. The distributing valve 35^b controlled by the device A will consequently be operated; the piston in cylinder 35 will be set in action, and motion will be transmitted to one end of the pair of levers 67. These levers will turn about the center 67* and their motion will be transmitted through the levers 64, links 63, levers 60, rod 86, and attached rods and levers to the distributing valve of the motor or motors employed to operate the steadying apparatus. Thus the motor 82, or the motors 97 (whichever is employed) will act to move either the weight 79 or the blades 96 or both (if both be employed together) into position to offer the necessary resistance to balance the turning moment or force exerted on the vessel. The vessel will thus be prevented from setting her masts at right angles to a wave acting upon her. When the piston 35^a moves, motion will be transmitted through the link 76, lever 75 and link 77 to the brush holder 29; this will so move the brushes around the commutator 27 as to break the circuit of the magnets 50 or 51 (as the case may be). Then the armature and connected distributing valve will be returned to their normal positions by the action of the spring 59, and the further movement of the piston 35^a will be prevented. Assuming the weight 79 to be the steadying device employed, as it is moved, the distributing valve of the motor that moved it will be gradually returned to its normal position by the lever 92 and rod 94. The movement of the weight will reduce the stability of the vessel. If this should cause the vessel to be inclined, or if the vessel should be inclined by any other cause, the vessel turning on an axis parallel to the axis of the long pendulum will cause the commutator 28 carried by this pendulum to turn relatively to the brushes thereon and will complete the circuit of one or other of the pairs of magnets in the valve operating device C. The distributing valve 37^b will thus be operated and the piston 37^a will be set in action. By it movement will be imparted to the levers 64 and 60 in a direction such as to neutralize the action on these levers of the piston 35^a. When the piston 37^a moves, motive fluid will flow through the passage 40 of cyl-

inder 37 and partly turn the piston 44. This piston will turn the attached commutator 47 into a position in which it will complete the circuit of one of the pairs of electro-magnets in the device B. This will cause the armature 52 of this device to turn and admit motive fluid to one or other end of the cylinder 36 causing motion of the piston 36^a. This motion will be transmitted through crosshead 69, levers 67 and attached levers 64, links 63, and levers 60 to the distributing valve of the motor or motors employed to operate the steadying apparatus which will then be moved into such a position as to resist rolling motion and tend to steady the vessel. When the piston 36^a moves, motion will also be transmitted through the link 71, lever 70 and segmental teeth on lever 45 to the brush holder 48 and brush 49. This will so move the brushes around the commutator 47 as to break the circuit of the magnets in the device B. If the vessel should roll independently of the action of waves upon it then the pistons 35^a and 37^a will be set in motion but in such directions that each will tend to balance the other and thus not to interfere with the vessel's stability; piston 36^a will at the same time be set in operation by the action of the piston 44 as just described, and will cause the levers 67 and 64 to be set in motion, the resultant motion of levers 64 being such as to cause the steadying apparatus to move into a position such that it will exert a resistance that will act to lessen or extinguish the rolling motion. This action is due to the secondary action of the long pendulum and takes place independently of either the vessel's position, or the action of waves thereon. Each pendulum will return to its normal position when the force which caused its movement, or relative movement, disappears. When returning, the pendulums will again move the commutators connected thereto, but in such a direction that a reverse movement will be given to the pistons 35^a, 36^a, and 37^a so that these pistons will return to their normal or mid positions when the pendulums assume their normal positions.

In order that the method of operation of the controlling apparatus may be fully understood the following further description or resumé is given:

The position of the three pistons in the three cylinders is governed by the two pendulums; the normal position of the pistons is at midstroke as shown in drawings; and this corresponds to the pendulums being in mid position and without motion. Motion of the short pendulum to any fixed position within the range of motion of the piston 35^a holds that piston in a particular position. Similarly the long pendulum governs piston 37^a, motion of which causes a temporary displacement of piston 36^a the extent to which this piston is displaced from midstroke depending on the rapidity of the motion of the piston 37^a. Thus the motion of levers 64 and 60 depends on the motion of all three pistons. The controlling apparatus governs the steadying gear by the motion of these levers. If the vessel be inclined in smooth water by some external force such as wind pressure, the short pendulum 1 will move its commutator 27 and cause a displacement of one end of the pair of levers 67 by the means hereinbefore mentioned, the extent of displacement depending on the angle to which the vessel is inclined if a small angle only be considered. The long pendulum at the same time, will cause an equal and opposite motion of piston 37^a. The levers 64 and 67 are so proportioned that under these circumstances no motion will be imparted to the levers 60 and there will therefore be no force brought into action tending to disturb the vessel's stability, due to the influence of the apparatus. Let the action of the apparatus be now considered when the vessel is rolling in smooth water. The pistons 35^a and 37^a, controlled directly by the short and long pendulums respectively, will again each neutralize the action of the other by equal and opposite movements, keeping time with the rolling, but arriving at full stroke after a small angle has been passed through by the vessel. The motive fluid in passing through the passage 40 of cylinder 37 will displace the piston 44 carrying with it the commutator 47 which brings into operation the device B (in the manner hereinbefore described) of cylinder 36 and causes piston 36^a to follow the motion of the piston 44 at the same time moving the brush holder 49, so as to break the circuit of the device B by means of the link 71 and lever 70. The piston 44 will be returned to its normal or mid position by means of a spring 44* (Fig. 1) when not disturbed by the motive fluid passing through the passage 40. The action of piston 36^a in the control is therefore to resist rolling motion. The action of the apparatus when the vessel is situated on the slope of a wave with its crest parallel to the length of the vessel differs from the previous cases. The direct action of the two pendulums will not then balance each other but the secondary action of the long pendulum will remain the same. If the vessel remains upright the long pendulum will be inactive, while the short pendulum 1 owing to its short period of oscillation, compared with the waves, will hang perpendicular to the wave slope, and will cause piston 35^a to be displaced, the amount of displacement depending on the steepness of the wave encountered, and if the steadying gear balances the action of the wave, no motion of the vessel will ensue. Should motion, due to a want of a correct balance, ensue, the long pendulum will first resist the motion and will afterward gradually adjust the stability so as to tend to restore steadiness. If the blades 96 be employed for steadying the ship, then, when the ship is subjected to a turning moment or force, or when she tends to roll, the motors

97 will be put in operation by the controlling apparatus through the intervention of the mechanism hereinbefore described. The blades will consequently be turned into positions in which the reaction between them and the water in which the vessel floats (provided she be under way) will be such as to counterbalance the turning moment or force, or will offer resistance such as to prevent or lessen rolling of the ship.

To avoid sparking between the brushes and commutators when breaking circuit, a resistance may be introduced into such circuit just before it is broken. This resistance may be placed in circuit, by one of the set of brushes that controls such circuit in a manner well understood.

What I claim is—

1. Apparatus for preventing or lessening the rolling of a vessel at sea, comprising a short period pendulum, a controlling motor, means controlled by said pendulum whereby the valve of said motor can be moved in one or other direction from its mid position when said pendulum moves from its normal position, mechanism controlled by the piston of said motor for closing said valve when said piston moves in either direction from its mid position, a steadying device adapted when moved out of its normal position to offer a resistance tending to balance a turning moment or force exerted on the vessel, a steadying motor for moving said steadying device in one or other direction, a valve for controlling said steadying motor, mechanism connecting the piston of said controlling motor with the valve of said steadying motor and acting to open said valve when said piston moves from its mid position, and mechanism connecting the valve of said steadying motor with said steadying device and acting to close said valve when said steadying device is operated, substantially as described for the purpose specified.

2. Apparatus for preventing or lessening the rolling of a vessel at sea, comprising a long period pendulum, a controlling motor, means controlled by said pendulum whereby the valve of said motor is moved in one or other direction from its mid position when said pendulum moves relatively to said vessel, mechanism controlled by the piston of said motor for returning the valve to its mid position when said piston moves in either direction from its mid position, a steadying device adapted when moved out of its normal position to offer a resistance tending to balance a turning moment or force exerted on the vessel, a steadying motor for moving said steadying device in one or other direction, a valve for controlling said steadying motor, mechanism connecting the piston of said controlling motor with the valve of said steadying motor and acting to open said valve when said piston moves from its mid position, and mechanism connecting the valve of said steadying motor with said steadying device, and acting to close said valve when said steadying device is operated, substantially as described for the purpose specified.

3. Apparatus for preventing or lessening the rolling of a vessel at sea, comprising a short period pendulum, a controlling motor, means controlled by said pendulum for opening the valve of said motor when said pendulum moves, mechanism controlled by the piston of said motor for closing said valve when said piston is set in motion, a long period pendulum, a second controlling motor, means controlled by said long period pendulum for opening the valve of said second motor when said long period pendulum moves relatively to said vessel, mechanism controlled by the piston of said second motor for closing the valve of said second motor when this piston is set in motion, an auxiliary motor adapted to be set in action by fluid entering and leaving said second motor, a third controlling motor, means controlled by said auxiliary motor whereby the valve of said third motor is opened when said auxiliary motor is set in action, mechanism controlled by the piston of said third motor for closing the valve of said third motor when the piston thereof is actuated, a lever jointed to the pistons of the first and third motors, a second lever jointed to the first one and to the piston of the second motor, a third lever jointed to said second lever, a steadying device adapted when moved out of its normal position to offer resistance tending to balance a turning moment or force exerted on the vessel, a steadying motor for moving said steadying device in one or other direction, a valve for controlling said steadying motor, mechanism connecting the said third lever with the valve of said steadying motor and acting to open said valve when said third lever is moved from its normal position, and mechanism connecting the valve of said steadying motor with said steadying device and acting to move said valve into its normal position when said steadying device is operated, substantially as described for the purposes specified.

4. Apparatus for preventing or lessening the rolling of a vessel at sea, comprising a sho t period pendulum, a controlling motor, an electro-magnetic device whereby the valve of said motor can be opened when the circuit of said device is closed, means for closing said valve when the circuit of said device is open, a circuit controller, one part of which is operated by said pendulum to complete the circuit of said electro magnet device, and another part of which is adapted to be operated by the piston of said motor to break the said circuit, a steadying device adapted when moved out of its normal position to offer a resistance tending to balance a turning moment or force exerted on the vessel, a steadying motor for actuating said steadying device, a valve for controlling said steadying motor, mechanism connecting the piston of said controlling motor with the valve of said steadying motor

and acting to open said valve when said piston moves from its normal position, and mechanism connecting the valve of said steadying motor with said steadying device, and acting to close said valve when said steadying device is operated, substantially as described for the purpose specified.

5. Apparatus for preventing or lessening the rolling of a vessel at sea, comprising short and long period pendulums, a first and second fluid pressure motor controlled by said short and long period pendulums respectively, electro magnetic devices each adapted when energized to open the valve of the corresponding motor in one or other direction, means for closing each of said valves when the circuit of the corresponding electro magnetic device is broken, circuit controllers for the respective pendulums, one part of each of these circuit controllers being operated by movement of the corresponding pendulum to complete the circuit of the corresponding electro magnetic device, and another part being operated by the piston of the corresponding motor to break the said circuit, an auxiliary motor adapted to be set in action by fluid entering and leaving said second motor, a third controlling motor, an electro magnetic device adapted when energized to open the valve of said third motor in one or other direction, means for closing said valve when the circuit of this last mentioned electro-magnetic device is broken, a third circuit-controller, one part of which is operated by a moving part of said auxiliary motor to complete the circuit of the third electro magnetic device, and another part of which is operated by the piston of the third motor to break the said circuit, an electric generator, electrical connections arranged substantially as described between the several electro-magnetic devices, circuit controllers and electric generator, a lever jointed to the piston of the first and third motors, a second lever jointed to the first lever and to the piston of the second motor, a third lever connected to said second lever, a steadying device adapted when moved out of its normal position to offer resistance tending to balance a turning moment or force exerted on the vessel, a steadying motor for actuating said steadying device, a valve for controlling said steadying motor, mechanism connecting the said third lever with the valve of said steadying motor and acting to open said valve when said third lever is moved from its normal position, and mechanism connecting the valve of said steadying motor with said steadying device and acting to close said valve when said steadying device is operated, substantially as described for the purposes specified.

6. In apparatus for preventing or lessening the rolling of a vessel at sea, the combination with short and long period pendulums, of suitable controlling motors, 35 36 and 37 each provided with a distributing valve, electro magnetic devices for the valves of said motors each comprising a pair of electro magnets arranged to be energized in turn, and each adapted to move the corresponding valve in an opposite direction to the other of the pair, and a spring device acting to return said valve to its mid or closed position, an auxiliary motor comprising a chamber arranged to form part of the passage leading to one end of the cylinder of the motor 37, a piston 44 arranged to oscillate in said chamber, a spring connected with said piston and tending to hold the same in its mid position, commutators 27, 28 and 47 actuated by said short period pendulum, long period pendulum, and piston 44 respectively, sets of brushes carried by brush holders 29, 30 and 48 respectively and each arranged to normally bear upon an insulated portion of the corresponding commutator, a lever 75 and links 76 and 77 connecting the piston of the motor 35 with brush holder 29, a lever 72 and links 73 and 74 connecting the piston of the motor 37 with the brush holder 30, a lever 70 connected with said brush holder 48 and connected with the piston of the motor 36, an electric generator, electrical connections arranged substantially as described between the said commutator, brushes, electro magnetic devices and electric generator, levers 67 pivoted to the cross head of motor 36 and jointed by links to the cross head of motor 35, levers 64 jointed to an intermediate part of levers 67 and jointed by links to the cross head of motor 37, levers 60 journaled on a cross shaft 61 and connected to intermediate parts of the levers 64, a steadying device adapted when moved out of its normal position to offer resistance tending to balance a turning moment or force exerted on the vessel, a steadying motor for actuating said steadying device, a valve for controlling said steadying motor, mechanism substantially as described connecting the said levers 60 with the valve of said steadying motor, and mechanism substantially as described connecting the said steadying device with the valve of said steadying motor, the whole arranged and operating substantially as herein described for the purposes specified.

7. In apparatus for preventing or lessening the rolling of a vessel at sea, the combination with long and short period pendulums, and controlling apparatus constructed and operating substantially as herein described, of steadying apparatus comprising a movable weight 79 fixed to a shaft 80 and mounted to turn about an axis inclined to the vertical in such a manner that it shall have a tendency to assume the fore and aft position and capable of being turned to either side of a central vertical plane passing longitudinally through the center of gravity of the vessel, a fluid pressure motor for actuating said weight, and provided with a valve, a lever connected to said valve for operating the same, mechanism connecting said controlling apparatus with the said valve lever and adapted to open said valve, said mechanism comprising a rod 86

connected at one end to said controlling apparatus, a curved slotted pivoted link 87 to which the other end of said rod 86 is jointed, a link 87^a having one end adjustably connected to said slotted link, a floating lever 92 connected to said valve, and connections between said rod 87^a and one end of said valve lever, and mechanism connecting the other end of said valve lever with the shaft carrying said weight 79 and acting to close said valve, said mechanism comprising an arm 95 and a link 94, substantially as herein described for the purposes specified.

8. In apparatus for preventing or lessening the rolling of a vessel at sea, the combination with long and short period pendulums, of rocking bearings wherein said pendulums are mounted, a motor and mechanism actuated by said motor and adapted to rock the bearings at the ends of each of said pendulums simultaneously in opposite directions, substantially as herein described for the purposes specified.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

JOHN ISAAC THORNYCROFT.

Witnesses:
THEODORE ALLPRESS,
JAMES G. STOKES.