E. A. SPERRY.

GYROSCOPIC APPARATUS FOR TORPEDOES.

APPLICATION FILED MAR. 15, 1916.

1,421,854.

Patented July 4, 1922.

2 SHEETS—SHEET 1.

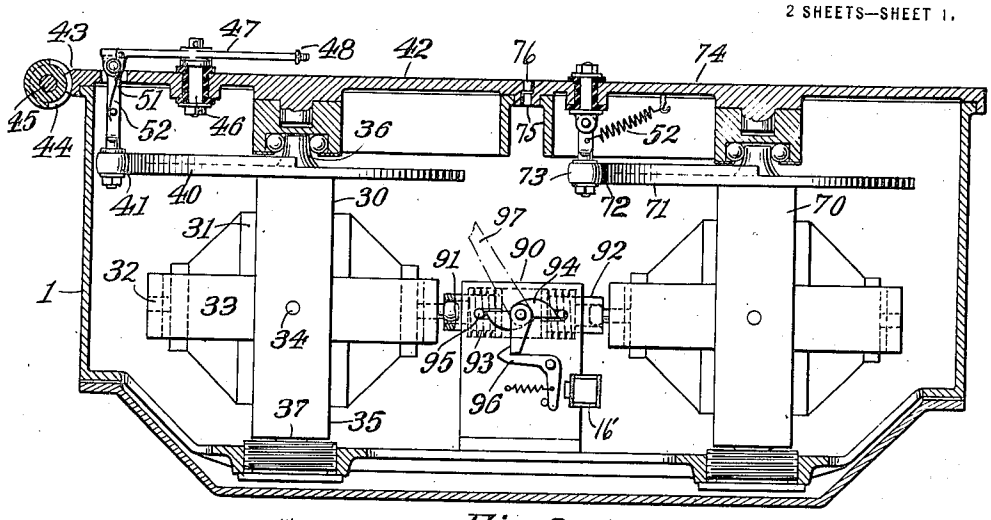

Fig. 2

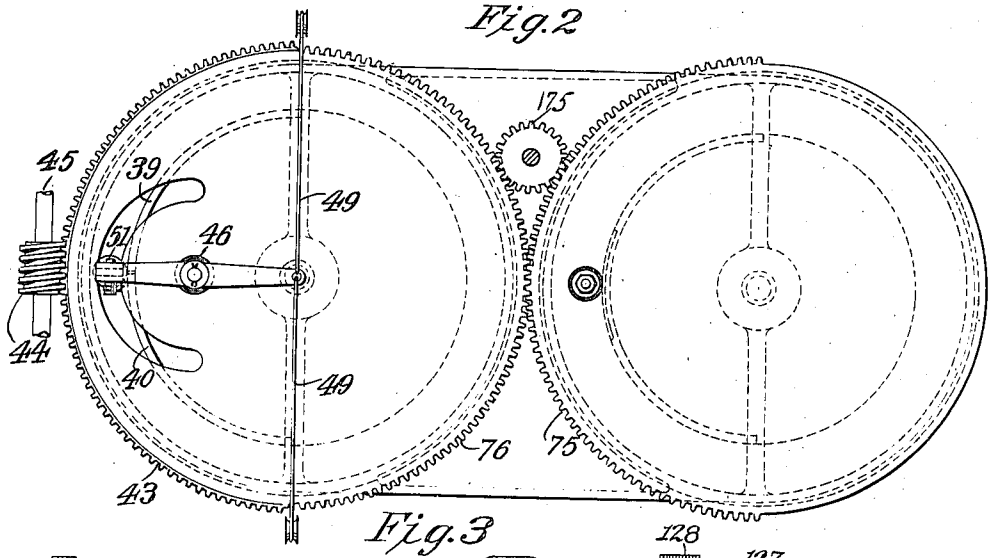

Fig. 3

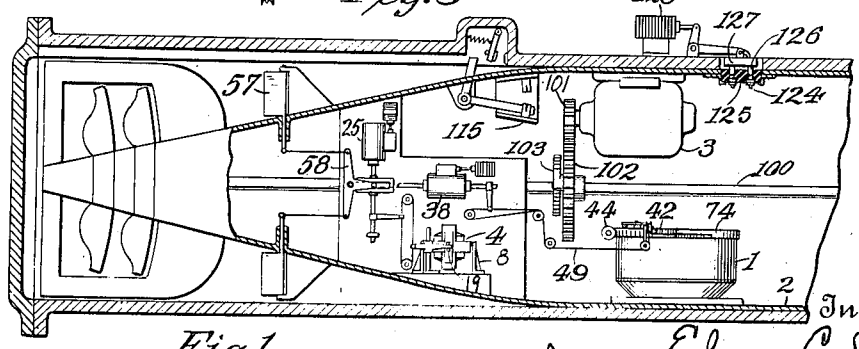

Fig. 1

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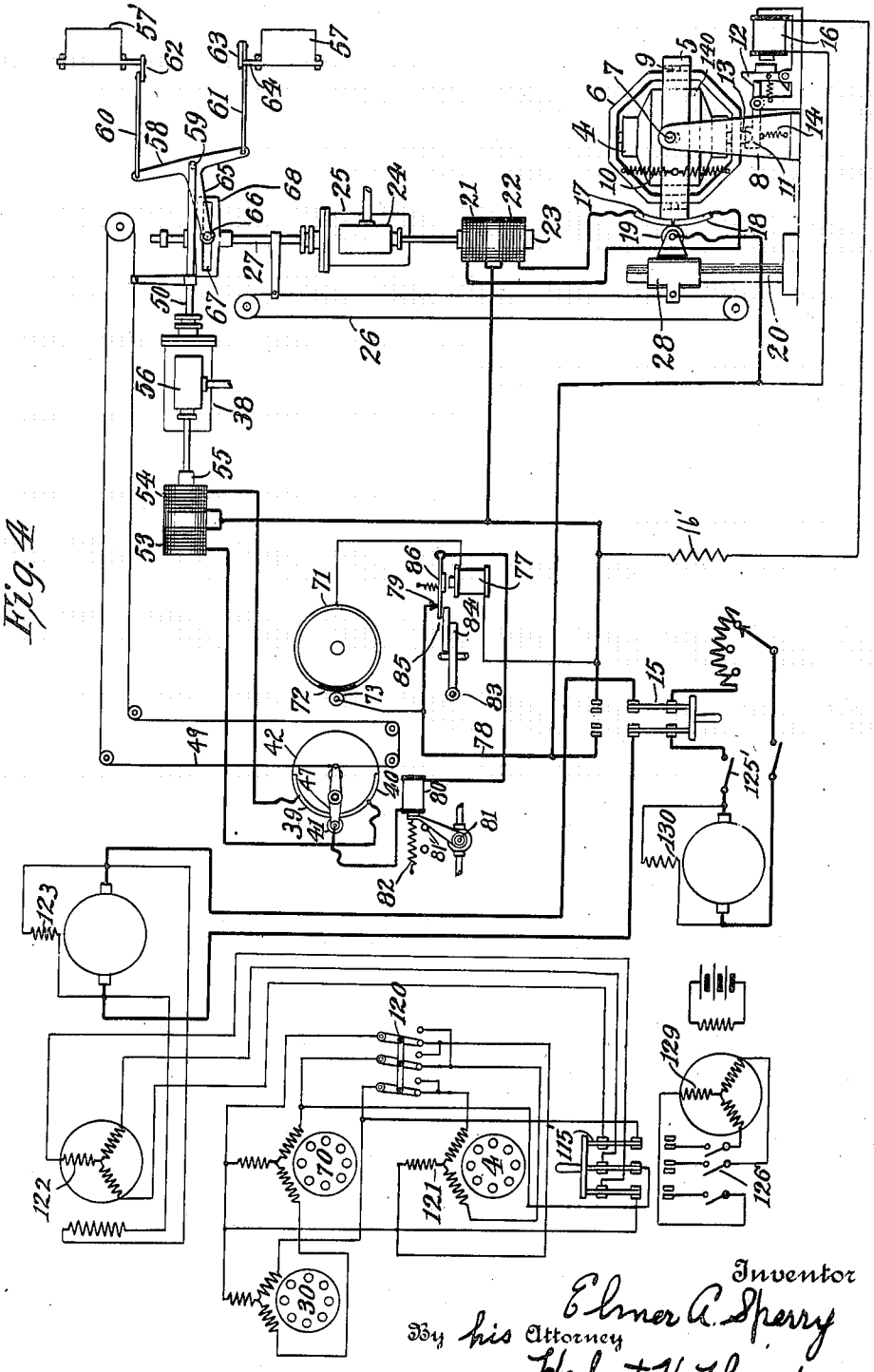
Fig. 4



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UNITED STATES PATENT OFFICE.

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GYROSCOPIC APPARATUS FOR TORPEDOES.

1,421,854. Specification of Letters Patent. Patented July 4, 1922.

Application filed March 15, 1916. Serial No. 84,292.

To all whom it may concern:

Be it known that I, ELMER A. SPERRY, a citizen of the United States, residing at 1505 Albermarle Road, Brooklyn, New York, in the county of Kings and State of New York, have invented certain new and useful Improvements in Gyroscopic Apparatus for Torpedoes, of which the following is a specification.

This invention relates to the steering of automobile torpedoes wherein one or more gyroscopes are used to keep the torpedo in its course. The main object of this invention is to increase the accuracy with which a torpedo may be fired by insuring the maintenance of a fixed reference plane from which the steering is controlled. In the present type of torpedo the rolling and pitching of the torpedo continually disturb this reference plane, so that even if the gyroscope remains undisturbed the torpedo is deflected from its course. Other causes for the same result are the list of the torpedo due to improper balancing, the list on angle firing and the continual yawing of the torpedo due principally to the hard over system of rudder control. I have discovered that unless the torpedo as a whole, or at least the contacts on the gyroscope which control the steering, are held fixed in a vertical plane, an error will result, due to the curvature of the earth which amounts to several minutes of arc in long range torpedo runs. In other words, unless the plane of control is at all times parallel to the earth's surface, the torpedo in following the earth's curvature will be gradually deflected from its course. A permanent list or an incomplete roll of the torpedo will hence cause deflection. Another object of the invention is to improve the steering control by eliminating the yawing due to said hard over system of the control. A third object is to provide a safety means whereby the torpedo is automatically stopped in case the steering control should become disabled or in case the torpedo should deviate more than a predetermined amount from its course. This becomes especially important when angle firing is employed, since if the steering control becomes disturbed during angle firing the torpedo is liable to turn through a complete circle and strike the ship from which it was sent. Other objects of the invention will be apparent as the description proceeds.

Referring to drawings in which what I now consider to be the preferred forms of my invention are shown: Fig. 1 is a vertical section of the stern of a torpedo within the firing tube showing my apparatus installed therein. Fig. 2 is an elevation partly in section of the steering control gyroscope, and an auxiliary gyroscope which I prefer to employ in connection therewith. Fig. 3 is a plan view of Fig. 2. Fig. 4 is a diagrammatic view showing the wiring diagram for driving the gyroscopes and the control of the steering engines and also showing schematically the mechanical connections between the various parts. The stabilizing gyroscope is also illustrated in this view.

For driving the gyroscopes I prefer to employ one of the systems disclosed in my co-pending application No. 47550—gyroscopic apparatus for torpedoes—filed August 26th, 1915. According to this system the gyroscopes are electrically sustained after the torpedo is fired and also preferably electrically started. In Fig. 1 the steering gyroscope is located within casing 1 within the shell 2 of the torpedo. A generator 3 driven from the main power source of the torpedo is used to furnish the power for the gyroscopes and also for any other purposes for which electricity may be desired within the torpedo, such as, for actuating or governing the steering engines and for driving any other gyroscopes that may be used. The generator is shown as geared to the propeller shaft 100 through gears 101 and 102 and pawl and ratchet 103.

In order to maintain the fixed reference plane described above I prefer to employ an auxiliary gyroscope 4 which serves to actuate stabilizing means such as fins or rudders without the torpedo upon rolling of the torpedo. The stabilizing gyroscope is preferably provided with three degrees of freedom as by being mounted within gimbal rings or casings 5 and 6. The rotor 140 is journalled in ring 6 on a normally vertical axis, the ring 6 being mounted on horizontal trunnions 9 in horizontal ring 5, which in turn is journalled on trunnions 7 in brackets 8 placed longitudinally within the torpedo. Pivots 7 are preferably located above the center of gravity of the system so that the system is pendulous about the fore and aft axis. The pivots 9, however, may support the ring 6 and the

rotor at about their center of gravity, so that the gyroscope is very little, if at all, pendulous about the transverse axis of the torpedo. For centralizing about said axis springs 10 extending between rings 6 and 5 may be provided. A lock 11 is provided to hold the gyroscope in a fixed position prior to launching. An automatic release is provided to throw out the lock upon launching. This may be in the form of a catch 12 which holds the lock 11 in engagement with the lug 13 on ring 6 against the action of spring 14. Upon the launching of the torpedo a switch 15 is thrown over as hereinafter explained, which serves among other things to excite the electromagnet 16 and withdraws catch 12 from lock 11. The gyroscope 4 is designed to maintain a horizontal plane within the torpedo irrespective of rolling. For this purpose contacts are arranged to be completed upon the rolling of the torpedo with respect to said plane. These contacts are shown as a pair of contact segments 17 and 18 mounted upon ring 5 with which the trolley 19, mounted upon a bracket 20 secured to the torpedo, is adapted to engage. Said contacts are in circuit with electro-mechanical means such as a pair of solenoids 21 and 22. Upon one or the other of the solenoids being energized the core 23 is moved accordingly. The core is connected to the slide valve 24 of the steering engine or cylinder 25 which may be actuated from the compressed air used for driving the torpedo. The engine 25 serves to actuate any form of suitable stabilizing fins, preferably of the type described hereinafter. A follow-up connection is preferably provided between the steering engine and the contacts in order to perform the usual functions of a follow-up device and prevent constant hunting of the parts. This is shown as a continuous wire 26 attached both to the piston rod 27 and to the slidable carriage 28 which supports trolley 19 from bracket 20. In order to have the stabilizing gyroscope maintain a fixed reference plane it is very important that the gyroscope be designed so that its natural period of oscillation bears a predetermined relation to the period in which the torpedo executes a turn of say 180°. It is found that when the relation between the total pendulous factor or ballistic properties of the gyroscopic pendulum and the gyroscopic moment at the normal speed of the gyroscope brings about a normal period of oscillation of the gyroscope in excess and preferably many times the time taken for the torpedo to turn through an arc of 180°, the disturbance due to such turning is reduced to a minimum and rendered so low as to be practically negligible. It should also be noted that by making the gyroscope pendulous only about the longitudinal axis of the torpedo, the effect of acceleration pressures due to the rapid acceleration of the torpedo in starting is largely eliminated.

Another important condition which fundamentally effects the performance of this type of gyroscope is its direction of rotation with respect to the direction in which the torpedo is turning on angle fire. I find it important to have the gyroscope rotating on its vertical spinning axis in the same direction in which the torpedo turns. When such is the case the deflection produced by the turn is markedly less than that produced by a turn in the opposite direction. In order to accomplish this purpose I prefer to provide a reversing switch 120 in circuit with the stator 121 of the stablizing gyroscope 4 so that the direction of rotation may be set according to the direction in which the torpedo is to be turned during angle firing.

The steering control proper is shown in Figs. 2 and 3. The main steering gyroscope 30 preferably consists of a rotor 31 mounted on a horizontal spinning axis 32 within the ring or frame work 33. The ring is mounted on horizontal trunnions 34 within the vertical ring 35 which in turn is pivotally mounted about the vertical axis in bearings 36 and 37 within the frame 1. The steering engine 38 (Fig. 4) may be similar in form to the stabilizing engine 25 and is controlled by the relative turning of the torpedo and the steering gyroscope about the vertical axis. For this purpose contacts 39 and 40 are attached to vertical ring 30 and the trolley or brush 41 mounted on some portion of the torpedo is in contact with said segments. I prefer to mount the trolley on a rotatable member 42 in order that the torpedo may be adapted for angle firing. For this purpose member 42 is provided with worm teeth 43 with which worm 44 meshes. The shaft 45 of worm 44 extends without the torpedo in the usual manner so that the member 42 may be set to the desired angle before launching. I also prefer to provide a follow-up connection between the steering engine 38 and the steering contacts. This result may be achieved by mounting trolley 41 on a lever 47, pivoted at 46 to member 42. The inner end 48 of said lever is connected by follow-up wires 49 with the piston rod 50 of engine 38 so that upon movement of said engine the trolley will be rotated around pivot 46. To provide for the irregular character of the movements which are imparted to the trolley 41 it may be pivoted to lever 47 as at 51 and pressed against the contacts 39 and 40 by means of a spring 52. The said contacts operate solenoids 53 and 54 which operate core 55 and valve 56 of engine 38 similarly to the corresponding parts of engine 25. A common locking means 90

may be used for both gyroscopes 30 and 70. This consists of a pair of locking bolts 91 and 92, normally retracted by springs 93. A cam member 94 serves to hold the bolts in the locking position by engaging pins 95 thereon. Upon the launching of the torpedo a catch 96 is released by magnet 16′ so that the springs 93 will withdraw the locks and incidently turn cam 94 back into a position from which it may reset the cam by being turned through a hand operated lever 97.

I prefer to both steer and stabilize the torpedo through the same rudders or fins 57 and 57′. For this purpose I connect piston rod 50 to a T-shaped member 58 by means of a pivotal connection 59. The two arms of member 58 are connected through links 60 and 61 to levers 62 and 63 and serve to rotate the rudders 57 and 57′ upon their rudder posts 64. The leg 65 of member 58 is provided with a pin 66 adapted to engage a slot 67 in a member 68 which is preferably secured to piston rod 27. The two engines are preferably placed at right angles to one another so that engine 38 will impart a translatory motion to member 58 while engine 25 will rotate member 58 about its pivotal connection 59 with piston rod 50. It will readily be seen that the links 60 and 61 when moved in the same direction by the translatory motion of member 58 will rotate rudders 57 and 57′ in the same direction and will, therefore, steer the torpedo, while movement of said links in opposite directions by rotation of member 58 will turn the rudders in opposite directions and thereby exert a powerful righting torque on the torpedo. It should also be observed that the torpedo can be both turned and rolled at the same time since the mechanisms are independent and do not interfere with one another.

As a means for preventing over running in angle firing I prefer to employ an auxiliary gyroscope 70 mounted adjacent the steering gyroscope 30 in a similar manner. A corresponding contact system is employed with reference thereto consisting of contact 71 and an insulated section 72 of a predetermined arc length. A trolley or brush 73, which bears thereagainst is mounted on a gear 74 similar to member 42 and driven therefrom by means of a pinion 175 meshing with teeth 75 and 76 on each member respectively. In circuit with the contacts 71 and 72 is an electro-magnet 77 adapted upon being excited to break the main control circuit 78 and 79 so that as soon as the torpedo turns more than a given number of degrees off its course the main circuit will be broken, whereby means may be brought into action to stop, destroy or disable the torpedo 2 so as to render it harmless. I prefer to stop the engine. In the main circuit I locate a second electro-magnet 80 which serves to hold the throttle valve 81 of the driving engine (not shown) in the open position so that when the main circuit is interrupted a spring 82 or other means will immediately close the throttle and shut off the engine. A pin 81′ serves to hold the throttle open before magnet 80 is excited and is withdrawn upon launching. Means are provided to prevent the operation of the safety device for a predetermined period after the torpedo is launched so that the safety device will not interfere with angle firing. For this purpose a worm and worm shaft 83 may be driven from some portion of the propelling mechanism. A worm wheel 84 meshing with said worm 83 carries a stop 85 which engages the pivoted armature 86 of electro-magnet 77 and thereby prevents the moving of said armature by the magnet until the stop is rotated from underneath the armature, that is, until the torpedo engine has completed a predetermined number of revolutions.

As above stated I prefer to employ the general electrical control system disclosed in my said co-pending application. According to this application the generator 3 located within the torpedo is provided with both A. C. windings 122 and D. C. windings 123. The former are used to drive all of the gyroscopes 4, 30 and 70, while the latter is employed to produce current for the control of the steering engines from the gyroscopes. In order that the gyroscopes may be spun up prior to launching or during the launching, I provide external connections 124 in the wall 2 of the torpedo whereby the current may be introduced from the external source into the torpedo. This connection 124 is shown in the form of a plug 125 of insulating material inserted within an opening in the wall of the torpedo and containing contact sockets adapted to receive the contact fingers 126 of plug 127. Means such as an electro-magnet 128 may be provided to withdraw the plug upon the launching of the torpedo. A double throw switch 115 is also preferably constructed to be actuated upon launching of the torpedo. This switch is adapted to disconnect the gyroscopes from the external source of supply and to connect them to the internal source of supply. Where an external A. C. source of supply is available such as represented by generator 129, switch 115 would serve to perform the function of switch 115′ in Fig. 4, while the breaking of the circuit at plug 126 is represented by 126′. Where the external source of supply is direct current as represented by generator 130 in Fig. 4 switch 115 performs the function illustrated by switch 15 in said figure, namely to connect the steering control system with the gen-

erator 123. The action of switch plug 125 and 126 is represented by 125'.

As soon as the torpedo is launched, the two generators 122 and 123 are driven from the propeller shaft and furnish current for accelerating and driving the gyroscopes and actuating the steering and stabilizing engines at the same time the gyroscopes are unlocked. If the torpedo turns from its course, a contact will be made through contacts 39, 40 and 41 and solenoid 53 and 54 will be excited to cause the steering engine 38 to turn the rudders 57 and 57'. The rudder will not be thrown hard over, however, as the follow-up connection 49 will cause it to be moved in small steps. Similarly, if the torpedo starts to roll, engine 25 will be actuated to keep it on an even keel. If the torpedo should run wild, the automatic engine stop 81 would be actuated as soon as the torpedo departed very far from its course.

In accordance with the provisions of the patent statutes, I have herein described the principle of 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 interference with the more general results outlined, and the invention extends to such use.

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

1. In an automobile torpedo, the combination with gyroscopic steering gear therefor, of means for stabilizing the reference plane, from which the steering is controlled, about the fore and aft axis of the torpedo.

2. In an automobile torpedo, means for stabilizing a reference plane for steering purposes comprising a gyroscope within the torpedo, and means responsive to relative movement between the gyroscope and the said plane for preventing departure of said plane from its initial position.

3. In an automobile torpedo, the combination with gyroscopic steering gear therefor, of means including a gyroscope for stabilizing the reference plane, from which the steering is controlled, about the fore and aft axis of the torpedo.

4. In a torpedo, a gyroscope, means responsive to turning of the torpedo about its vertical axis with respect to the gyroscope for steering the torpedo, a second gyroscope and means controlled by said second gyroscope for preventing departure of the reference plane of control from its original position.

5. The combination with an automobile torpedo, of a gyroscope mounted therein, stabilizing means without the torpedo, and means responsive to relative movement of the torpedo and gyroscope about the fore and aft axis for controlling said stabilizing means.

6. The combination with an automobile torpedo adapted for angle firing, of a gyroscope mounted therein with three degrees of freedom on a normally vertical spinning axis, spinning means for said gyro, and means whereby the direction of spin produced by said means may be set with reference to the rotational direction of the torpedo when turning during angle fire.

7. The combination with an automobile torpedo adapted for angle firing, of a gyroscope mounted therein with three degrees of freedom on a normally vertical spinning axis, said gyroscope being pendulous about the fore and aft axis of the torpedo, spinning means for said gyro, and means whereby the direction of spin produced by said means may be set with reference to the rotational direction of the torpedo when turning during angle fire.

8. In an automobile torpedo, the combination with a plurality of rudders, mechanism connected therewith for rotating them in the same direction for steering the torpedo and for rotating them in different directions for exerting a rolling torque on the torpedo.

9. In an automobile torpedo, the combination with a plurality of rudders, a rocker arm connected therewith, a steering engine connected to said arm so as to impart a translatory motion thereto, a stabilizing engine connected therewith so as to impart an angular motion thereto, whereby the rudders are moved together for steering and reversely for stabilizing.

10. A steering mechanism for automobile torpedoes comprising a gyroscope, contacts operable between it and another member, a steering engine, a rudder controlled thereby, and a follow-up connection between a moving portion of the steering mechanism and said contacts.

11. In an automobile torpedo, a gyroscope, means for stopping the propellers, and means responsive to departure of the torpedo of more than a predetermined amount from a predetermined relation to the gyroscope for operating said stopping means.

12. In an automobile torpedo, a gyroscope, means for stopping the propellers, means responsive to departure of the torpedo of more than a predetermined amount from a predetermined relation to the gyroscope for operating said stopping means, and means for preventing the operation of said second mentioned means during the initial part of the torpedo's run.

13. In an automobile torpedo, a gyroscope,

a steering engine, means responsive to the apparent movement of the gyroscope for controlling the steering engine, an auxiliary gyroscope and means responsive to a predetermined apparent movement of said auxiliary gyroscope for rendering said steering control means inoperative.

14. In a torpedo, a stabilizing means comprising a gyroscopic pendulum mounted within the torpedo having a natural period in excess of the time normally taken by the torpedo to turn during angle firing, and means responsive to relative movement between the torpedo and the pendulum for exerting a righting torque on the torpedo.

15. In a torpedo, a gyroscopic stabilizer comprising a rotor and rotor bearing frame, an outer gimbal ring supporting said frame on transversely extending trunnions near its center of gravity, said ring being supported above its center of gravity on longitudinally extending trunnions and resilient centralizing means connecting said frame and said ring.

16. In an automobile torpedo, means for stabilizing a reference plane for steering purposes comprising a gyroscope mounted upon a vertical spinning axis with three degrees of freedom, and means responsive to relative movement between the gyroscope and the said plane for preventing departure of said plane from its initial position.

17. In an automobile torpedo, a steering gyroscope, an auxiliary gyroscope, means for rendering the torpedo harmless, and means responsive to departure of the torpedo of more than a predetermined amount from its normal relation to the auxiliary gyroscope for operating said first mentioned means.

18. In an automobile torpedo, the combination with an external source of electrical energy, of an electro-motor gyroscope therein, a locking means therefor, means for introducing current through the wall of the torpedo to said gyroscope for initially spinning it up, an internal source of electrical energy, means for unlocking said gyroscope and means for conveying electrical energy to the gyroscope from the internal source when the energy from the external source is discontinued.

19. In an automobile torpedo, a gyroscope, a steering engine, means responsive to the apparent movement of the gyroscope for controlling the steering engine, an auxiliary gyroscope, means for rendering the driving means ineffectual and means responsive to a predetermined apparent movement of said auxiliary gyroscope for operating said last mentioned means.

20. In an automobile torpedo, the combination with a steering gyroscope having freedom around vertical and horizontal axes, means mounted on the gyroscope for movement therewith about the vertical axis, cooperating means mounted adjacent thereto, said two means being adapted to control the steering engine and means for stabilizing said two controlling means.

21. In an automobile torpedo, the combination with a steering gyroscope having freedom around vertical and horizontal axes, means mounted on the gyroscope for movement therewith about the vertical axis, cooperating means mounted adjacent thereto, said two means being adapted to control the steering engine, and means for maintaining a fixed relation about the fore and aft axis between the gyroscope proper and the said two means.

22. In an automobile torpedo, the combination with a plurality of rudders, an automatic steering engine connected therewith for rotating them in the same direction for steering the torpedo, and an automatically controlled stabilizing engine connected therewith for rotating them in different directions for exerting a rolling torque on the torpedo.

In testimony whereof I have affixed my signature.

ELMER A. SPERRY.