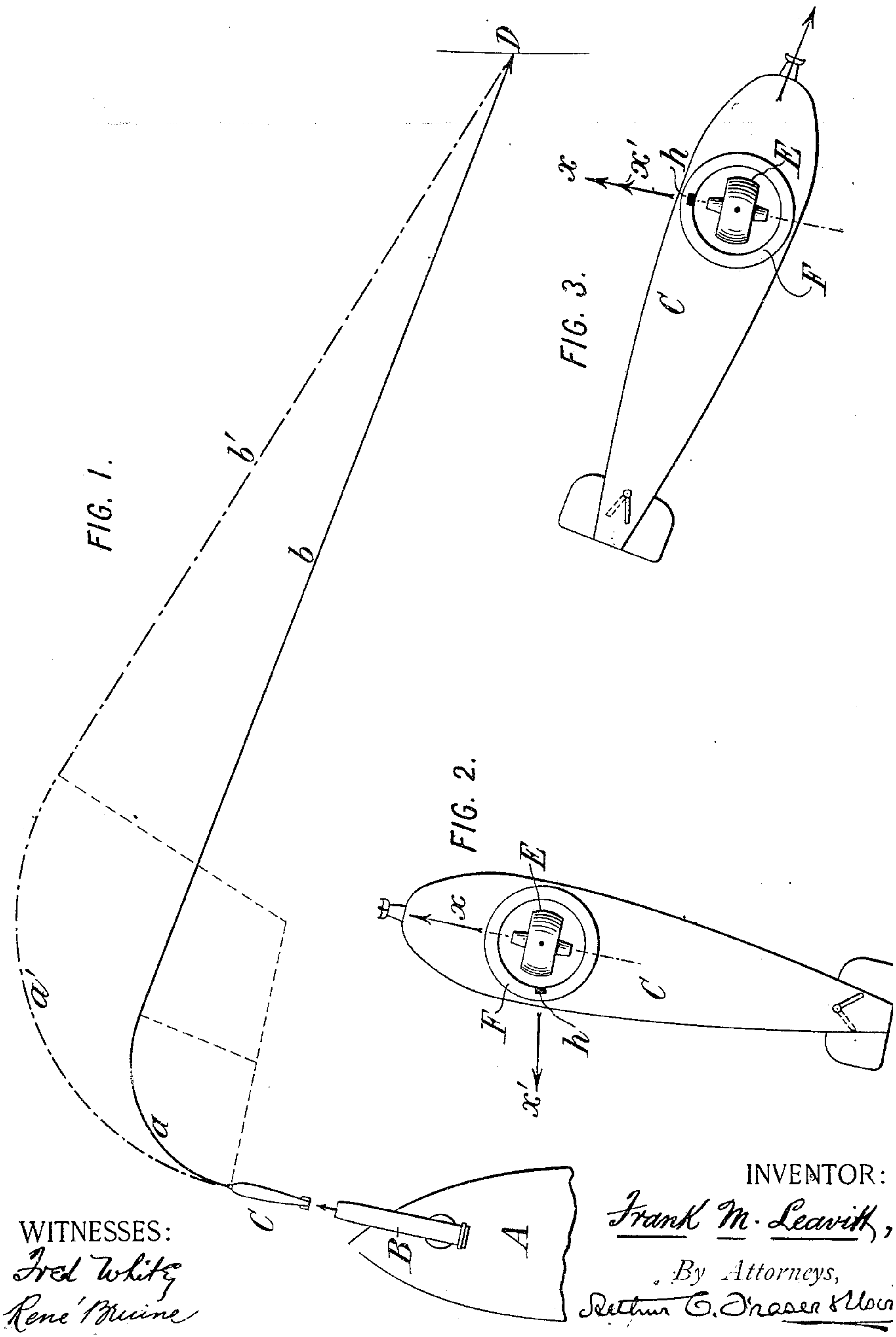
No. 839,161. PATENTED DEC. 25, 1906.

F. M. LEAVITT.

STEERING APPARATUS FOR AUTOMOBILE TORPEDOES.

APPLICATION FILED JAN. 20, 1906.

4 SHEETS—SHEET 1.



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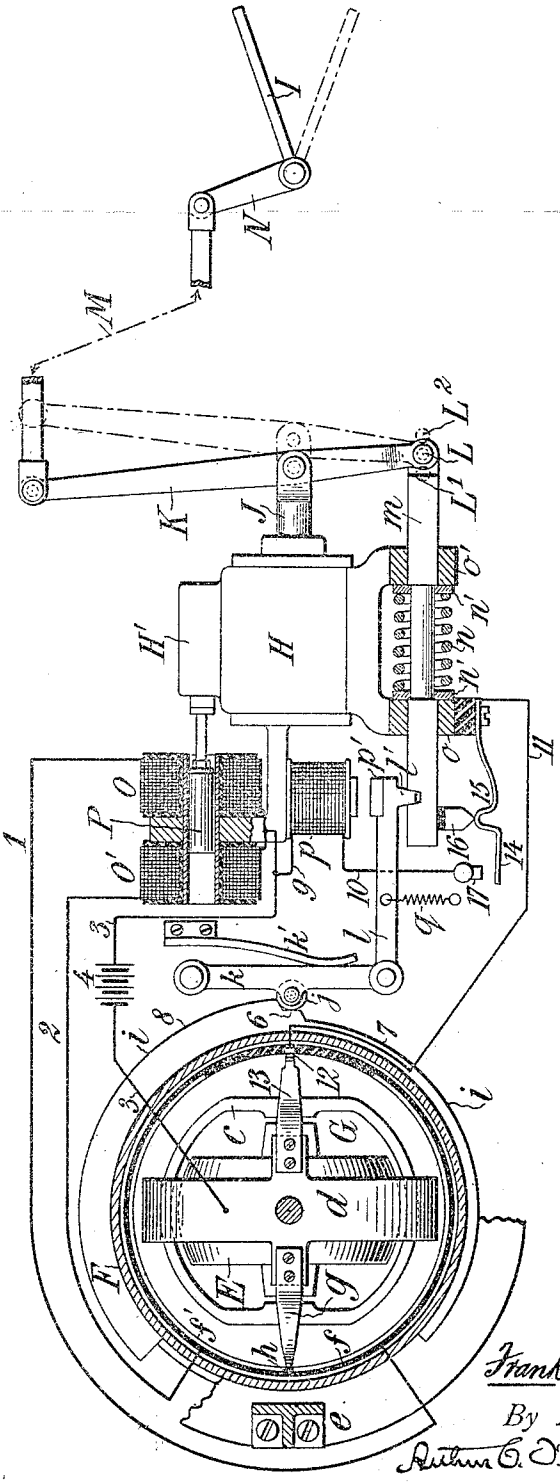
4 SHEETS—SHEET 2.

FIG. 4.



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4 SHEETS—SHEET 3.

FIG. 5.

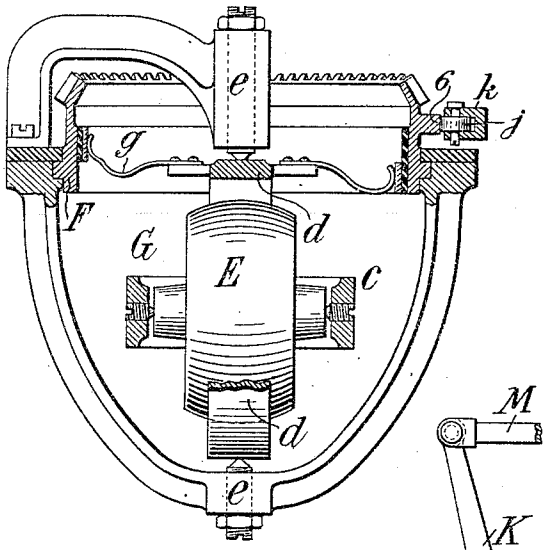

FIG. 6.

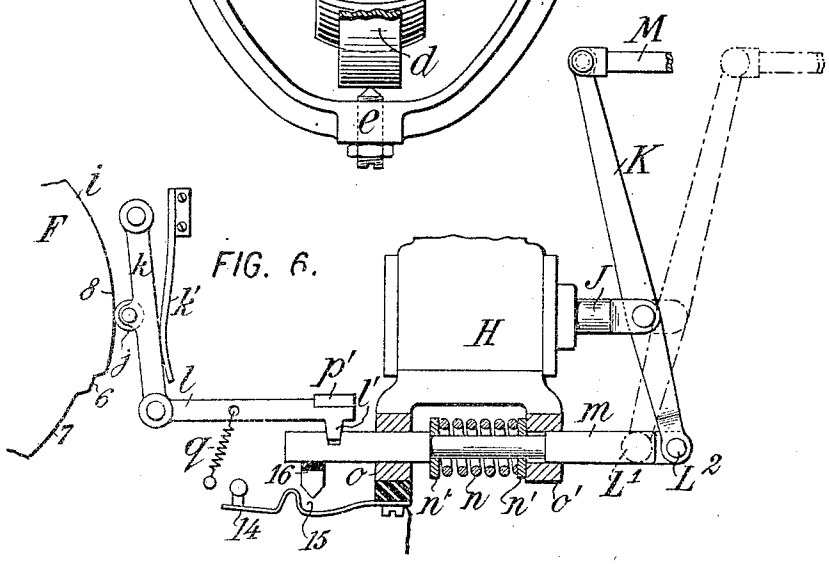

FIG. 7.

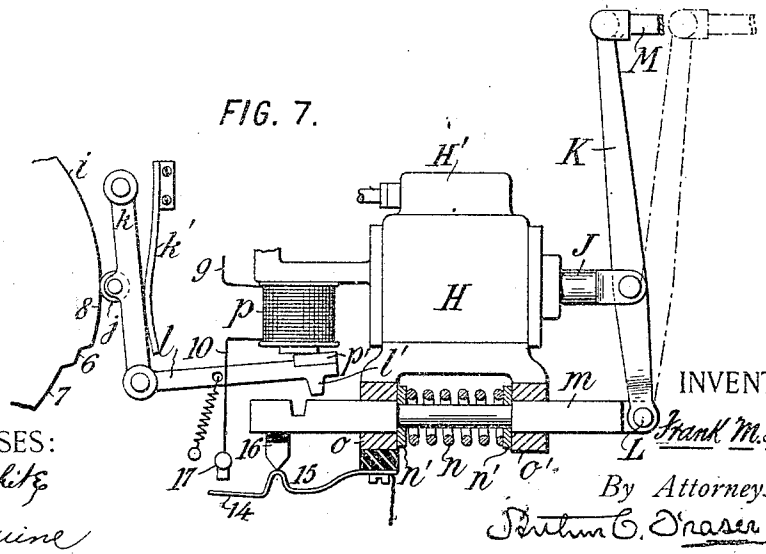

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FIG. 8.

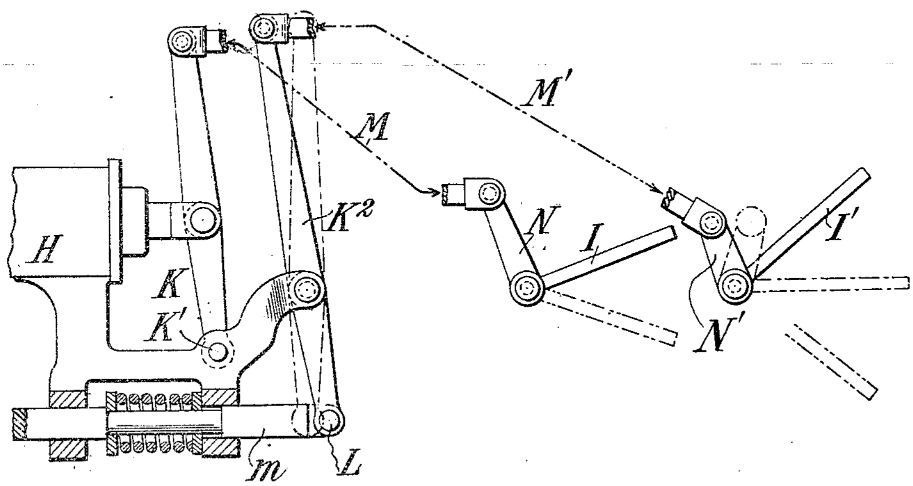
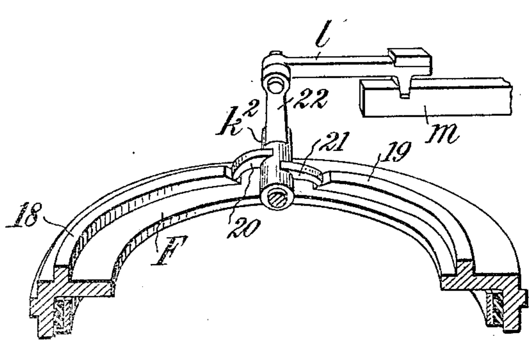


FIG. 9.



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UNITED STATES PATENT OFFICE.

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STEERING APPARATUS FOR AUTOMOBILE TORPEDOES.

No. 839,161. Specification of Letters Patent. Patented Dec. 25, 1906.

Application filed January 20, 1906. Serial No. 296,992.

To all whom it may concern:

Be it known that I, FRANK M. LEAVITT, a citizen of the United States, residing in the borough of Brooklyn, county of Kings, city and State of New York, have invented certain new and useful Improvements in Steering Apparatus for Automobile Torpedoes, of which the following is a specification.

This invention relates to gyroscopic steering mechanisms for automobile torpedoes. Its purpose is to more perfectly adapt the torpedo to what is technically known as "wide-angle" fire—that is to say, to enable the torpedo to be aimed in a direction differing by a wide angle from the course which it is designed to take, the steering mechanism being previously set to cause it to steer in a circle until it shall have compensated for the angle of divergence and reached its ultimate course, where it is headed toward the target. In the normal steering of the torpedo when on such ultimate course the rudder deflection to extreme port or starboard is limited in order that the slightly sinuous course steered by the torpedo shall not differ seriously from the straight-line course toward the target which it should follow. This normal deflection of the rudder determines the radius of the circle in which the torpedo may steer when the rudder is held hard over, the diameter of this circle being what is known as the "tactical diameter" of the torpedo. For the best steering upon a normal course the tactical diameter is so large that in firing the torpedo at an angle widely divergent from its ultimate course the circular course on which it initially steers is of undesirably large radius, so that too much of its energy is wasted in traversing the initial circular course and the accuracy of aim is impaired by reason of the angle between its ultimate course and a direct line from its point of firing to the target being too great.

The object of the present invention is to decrease the tactical diameter of the torpedo during the time that it is steering its initial circular course and to restore the normal tactical diameter upon the termination of this initial course and the beginning of the ultimate direct course of the torpedo toward the target.

To attain this object, the present invention provides means whereby in setting the steering apparatus to steer through any angle of divergence from the line of fire it shall be caused while steering through such angle to exert a greater deflecting effect upon the torpedo than during the normal steering action, whereby to diminish the radius of the circular arc through which the torpedo initially steers, or, in other words, to decrease its tactical diameter. With this is combined means under the control of the gyroscope for terminating the effect of such initial steering means as soon as the torpedo shall have reached a position in alinement with the target, or, in other words, shall have headed upon its ultimate course, so that thereafter the deflecting effect of the steering apparatus shall be reduced to the normal, thereby increasing the tactical diameter to that which gives the best results in normal steering.

In carrying out this invention the normal steering apparatus is provided with what for convenience will be called an "angle-gear," which is brought into operation when the steering apparatus is set to operate at an angle diverging from the line of fire and when so set is adapted to turn the rudder to the appropriate side to a greater degree than that assumed by it when thrown hard over in normal steering. Other means of increasing the initial deflection of the torpedo while steering the preliminary arc or circular course will be within the present invention; but the simplest and most desirable means is that stated, wherein the normal deflection of the rudder is increased to a considerable extent during the steering of this preliminary circular course.

In the accompanying drawings, Figure 1 is a diagram showing a torpedo in the act of launching and its course toward its target. Fig. 2 is a diagram of the torpedo, on a larger scale, showing its gyroscope and showing diagrammatically a means for angular displacement. Fig. 3 is a similar diagram to Fig. 2, but showing the torpedo headed upon its ultimate course. Fig. 4 is a plan, partly in horizontal section, showing a suitable form of the mechanism for carrying out the present invention. Fig. 5 is a vertical section showing a gyroscope-support and turntable pertaining to the angle-gear. Fig. 6 is a sectional plan, being a fragment of Fig. 4, showing the parts in a different position. Fig. 7 is a similar view showing the parts in

still another position. Fig. 8 is a fragmentary and partly-sectional plan view corresponding to Fig. 6 and showing a modification. Fig. 9 is an oblique elevation of the turn-table and connected mechanism illustrating a modification.

Referring first to Fig. 1, let A designate a torpedo-boat, and B a launching-tube carried thereby, shown in the act of launching a torpedo C. The target which the torpedo is to strike is lettered D. Since the direction of aim of the torpedo-tube B is not toward or in line with the target, but diverges therefrom at a considerable angle, it is necessary that the torpedo when launched shall first steer through a circular course or initial arc *a* until it is headed toward the target, whereupon it follows its ultimate course *b*, which is a tangent to the arc *a*.

In Figs. 2 and 3 the torpedo is shown on a larger scale, and in it is shown of disproportionate size its gyroscopic fly-wheel E. In the act of launching, this wheel is spun up to a high velocity, with its axis *x* in a direction having a fixed reference to the ultimate course *b*. For example, the axis *x* may coincide with the axis of the launching-tube, so as to vary by a given, but variable, number of degrees from the ultimate course *b*. For example, let it be assumed that the divergence in a given case is fixed at one hundred degrees. Then by turning a ring or turn-table F in the contrary direction through the same number of degrees as indicated in Fig. 2, so that its axis *x'* diverges one hundred degrees from the fly-wheel axis, the torpedo must with a suitably-constructed steering apparatus steer through the same number of degrees, so as to bring the axis *x* into coincidence with the axis *x'*, as shown in Fig. 3, whereupon, the torpedo having reached its ultimate course, it is required to steer no longer in an arc, but in a substantially straight line toward the target. As already explained, it is desirable that the initial arc *a* be of as short radius as practicable in order to avoid loss of time and waste of energy and to avoid also the occurrence of too great an angle between the ultimate course *b* and a direct line from the firing-point to the target.

Fig. 1 shows in dotted lines an initial arc *a'* and an ultimate course *b'*, which may be assumed to be such as would be steered if the steering apparatus exerted the same deflecting moment during the steering through the initial arc that it does or should upon the normal steering upon a substantially straight course. It is to be understood that owing to the want of space afforded for such a diagram the relation between the course shown by the dotted line *a' b'* and that shown by the full line *a b* is somewhat disproportionate or exaggerated. Nevertheless the diagram will serve to illustrate in principle the loss of time and energy involved in traversing an arc *a'* of large radius as compared with an arc *a* of small radius and also the inaccuracy of aim involved by reason of the ultimate course *b'* varying by a wider angle from the direct line of sight toward the target than does the ultimate course *b*.

One suitable means for giving the steering apparatus a greater deflecting moment while traversing the initial arc than subsequently is by causing it to turn the rudder to a greater angle. For example, assuming the normal deflection of the rudder when hard over on either side to be twenty degrees (see Fig. 3) from the longitudinal axis, the rudder may be set over to a greater angle—say forty degrees (see Fig. 2)—while traversing the initial arc. To enable the means for accomplishing this to be understood, a suitable form of gyroscopic steering apparatus to which my present invention is applicable will first be described with reference to Figs. 4 and 5. Let G designate as a whole the gyroscope, the fly-wheel E of which has been already referred to. The means for initially spinning up the gyroscope is not shown, being well understood. Such a gyroscope includes inner and outer gimbal-rings *c d*, the former pivoted to the latter upon a horizontal axis transverse to the fly-wheel axis, the outer ring being pivoted upon a vertical axis in a fixed frame *e*. The precise construction of the gyroscope is immaterial to the present invention. The gyroscope controls in any suitable manner a steering device H, which may, for example, be a steering-engine or servomotor driven by compressed air, such as is well known in the Whitehead torpedo. This steering-engine through any suitable connection operates the rudder I. Preferably the steering-engine engages through a rod J, which may be its piston-rod, with a lever K fulcrumed at L and having its opposite or free end connected by a rod M to the tiller N, which controls the rudder. The valve H' of the steering-engine is operated under control of the gyroscope by any suitable interconnecting means—such, for example, as a double solenoid O O', the core P of which is connected by a rod or otherwise to the valve. The solenoid-coils O O' are connected, respectively, through conducting wires or circuits 1 and 2 to conducting-segments *f f'*, which are swept by a contact arm or spring *g*, which is carried by the outer ring *d* of the gyroscope, the latter being in connection through a wire or circuit 3 with a battery or dynamo 4 and with the opposite terminals of the coils O O', as clearly shown. The contact-strips *f f'* are carried upon a part or ring F, having normally a stationary relation to the hull of the torpedo. It results that when the torpedo is so deflected relatively to the axis of the gyroscope fly-wheel the spring *g* touches one or other of the contact strips or segments *f* or *f'*,

the circuit is closed through one or other of the coils O O′, and the coil thus energized attracts the core P and moves the valve to operate the steering-engine, which turns the rudder in such direction as will steer the torpedo to port or starboard, as the case may be, until the opposite segment *f* or *f′* is moved around into contact with the spring *g*, which by reason of the persistence of direction of the gyroscope-axis remains substantially immovable, whereupon the coil O or O′ previously active is deënergized and the other coil is energized and attracts the core to it, thereby shifting the valve and causing the engine to throw the rudder to the opposite side. This is the normal action of a steering-engine of this type in steering alternately to port and starboard in order to direct the torpedo upon a slightly sinuous course, crossing and recrossing a straight line constituting its theoretical or approximate course toward the target. The mechanism thus described is an old and well-known steering mechanism and forms no necessary part of my present invention, but is here illustrated because it affords a suitable apparatus to which to apply this invention and by which it may be readily understood. With such a gyroscopic steering mechanism it has been proposed to cause the torpedo to steer through an initial arc, such as *a′*, Fig. 1, by initially turning the ring or turn-table F, carrying the contact-segments *f f′* in a direction contrary to that which the torpedo is to steer and through as many degrees as it is to turn in traversing this initial arc. It results from this that at the moment of launching the contact-spring *g* touches one of the segments *f* or *f′* at a point remote from the zero-point *h* between the approaching ends of the segments by as many degrees as the displacement of the ring F and that consequently the steering apparatus will hold the rudder hard over to the appropriate side in order to steer the torpedo through such initial arc. While traversing such initial arc the torpedo is turned constantly to port or starboard, carrying with it the ring F, while by reason of the persistence of direction of the gyroscope its axis continues to point in the original direction, so that the spring *g* does not turn. This condition continues until the segment *f* or *f′* passes out of contact with the spring *g* upon the arrival of the zero-point *h* in coincidence therewith, (this being the position shown in Fig. 4,) at which point the torpedo is headed upon its ultimate course, as indicated in Fig. 3. Instantly thereafter the opposite segment contacts with the spring *g*, and the opposite solenoid O or O′ is energized, thereby throwing the rudder to the opposite side and terminating the steering upon the initial arc. After this instant the torpedo steers in the normal manner upon its ultimate course, such as *b′*, Fig. 1.

The present invention may now be understood. It being desirable for reasons already explained to diminish the tactical radius of the initial arc, the torpedo is given an increased steering moment or tendency while traversing this initial arc. This increased moment is most conveniently accomplished by giving the normal steering-rudder I an increased deflection. For example, if the normal deflection is twenty degrees to either side of the longitudinal axis of the torpedo its deflection during the initial arc may be increased, say, to forty degrees. The means shown for accomplishing this is a shifting of the fulcrum-point L, on which the lever K turns. This fulcrum-point is shown in full lines in its normal or central position in Fig. 4 and is displaced therefrom in the appropriate direction to the points indicated by the dotted circles L′ L², as the case may be. This displacement throws the lever K to a greater angle, so that its free end connecting with the steering-rod M is carried farther from the central point, and thereby turns the rudder to a greater angle. The lever is shown thus displaced in Fig. 6.

The direction of displacement of the fulcrum-point L depends upon the direction to which the lever is thrown by the steering-engine H—that is to say, if the steering-engine has moved the lever to steer to starboard the fulcrum-point L is displaced in the opposite direction to L² in order to increase the deflection of the lever K and throw the rudder farther to starboard. This displacement of the fulcrum-point may be variously accomplished. Preferably it is performed by a connection with the ring or turn-table F, so that the turning of this ring or turn-table to cause the torpedo to steer through an initial arc to either port or starboard automatically determines the appropriate displacement of the fulcrum-point L. This is best accomplished by means of a cam formed or provided on or connected with the ring F and having some suitable mechanical or other equivalent connection with the fulcrum-point. A simple and suitable mechanism for performing these functions is that shown. The ring F is shown as provided with a cam-surface *i*, engaging an antifriction-roller *j*, carried, preferably, by an arm or lever *k*, which may have a spring *k′* pressing it against the cam, this lever being connected by an arm *l* with a slide *m*, which carries the fulcrum-point L. When the ring F is in its normal position, an intermediate portion 6 of the cam-face *i* is in contact with the roller *j*, and the position of the parts is that shown in Fig. 4, where the fulcrum-point L is in its normal or intermediate position. The displacement of the ring F to either port or starboard carries a higher or lower portion 7 or 8 of the cam-surface into contact with the roller *j*, thereby displacing the lever *k* either inwardly

or outwardly and communicating a corresponding displacement through the parts *k l m* to the fulcrum-point, thereby displacing it in one direction or the other to the position L′ or L², as the case may be. It is shown thus displaced to the position L² in Fig. 6. This displacement is accomplished against the stress of a spring *n*, which tends to restore the slide *m* to its intermediate position. This spring may conveniently act against washers *n′* at opposite ends, which washers are engaged by reduced portions or shoulders on the slide and by the faces of the supporting slideways or brackets *o o′*, through which the slide moves.

The mechanism last described is adapted to increase the deflection of the rudder, and thereby steer an initial arc of diminished radius; but it would derange the normal steering action if means were not provided for terminating its operation as soon as the steering through the initial arc has been accomplished and the torpedo is headed upon its ultimate course *b*. To accomplish this, some means must be provided for disconnecting the part carrying the fulcrum L from the cam *i*, pertaining to the ring or turn-table F. A convenient means for accomplishing this disconnection is that shown, where the arm *l* may be disengaged from the slide *m* upon the zero-point *h* of the turn-table coinciding with the spring *g* of the gyroscope. This disconnection may be variously accomplished; but a simple and convenient means is through an electromagnet *p*, the armature *p′* of which is mounted on the arm *l*, the latter being normally pressed away from the magnet by a retracting-spring *q*. The arm *l* may engage the slide *m* by having a tooth *l′* entering a notch in the slide, as shown. The magnet *p* has its coil in a circuit connecting through wire 9 with the battery 4 and through wires 10 and 11 with a contact-segment 12, carried by the ring F, and with which contacts an arm or spring 13, carried by the ring *d* of the gyroscope, the contacts 12 and 13 being in such position that they touch when the contact-spring *g* coincides with the zero-point *h*. It results that in this position the circuit 3 4 9 10 11 12 13 is closed, energizing the magnet *p*, which draws back the arm *l* so as to disconnect it from the slide *m*, as shown in Fig. 7. Thereupon the spring *n* presses back the slide to its normal or central position, thereby restoring the normal position of the fulcrum L and adapting the steering apparatus for steering normally upon the ultimate course *b*. With such an electromagnetic means for restoring the fulcrum to its normal position it is desirable in order to avoid waste of electric energy to provide for breaking the circuit to the magnet *p* as soon as it has done its work. This may be accomplished by a circuit-breaking spring 14, having a projection or hump 15, engaged by a cam projection 16 on the slide *m* so as to press the spring 14 away from its contact-point 17. Upon the original displacement of the slide *m* by the action of the cam *i* its projection 16 moves out of coincidence with the hump 15, as shown in Fig. 6, thereby permitting the spring 14 to touch the contact 17 and completing the circuit in readiness for its closure when the contact-spring 13 touches the segment 12. When the magnet *p* acts and the slide *m* returns to its central position, its projection 16 wedges against the hump 15, and thereby forces the spring 14 out of contact with the stop 17 and breaks the circuit, as shown in Fig. 7. This same circuit-breaker is useful to prevent needless action of the magnet *p* when the angle-gear is not set for operation—that is to say, when the ring F has its zero-point *h* in its normal position coinciding with the contact-spring *g*, so that the torpedo when launched will steer a straight course ahead.

After the run of the torpedo it is necessary to move its ring F back to its normal position so as to bring the cam portion 6 against the wheel *j* and move the arm *l* to its central position, so that its tooth *l′* may reëngage the notch in the slide *m*, after which the ring F may be turned in either direction in order to reset the angle-gear for steering an initial arc in the desired direction before again launching the torpedo. Instead of causing the angle-gear to give the increased steering moment by increasing the deflection of the rudder, the increased steering moment may be accomplished by other means. An example thereof is shown in Fig. 8, where the lever K is operated solely from the steering-engine H, turning around a fixed fulcrum-point K′ and through a rod M and tiller N, steering the rudder I, this being the normal steering apparatus, while for steering in the initial arc a separate rudder I′ is provided which may be larger than the rudder I or may be turned to a greater angle and is operated by the angle-gear by means of the same slide *m*, carrying the movable fulcrum L, which acts through an auxiliary lever K², rod M′, and tiller N′ to turn the supplemental rudder I′. At the termination of the initial arc and at the instant when the rudder I swings over to the opposite side the release of the slide *m* in the manner already described moves the fulcrum L to its central position and through the lever K², rod M′, and tiller N′ moves the rudder I′ to its central or midships position, as shown in dotted lines, and holds it there during the remainder of the run of the torpedo. The advantage of the mechanism first described is that it accomplishes the desired result more simply, requiring only one rudder, one lever, and one intermediate connection instead of two.

The details of the mechanisms described may be greatly varied without departing from the invention. For example, other forms of cam may be used in place of the cam *i* with its successive faces 6, 7, and 8. One such modification is shown in Fig. 9, where the ring F has cam-ribs 18 19 extending in arcs of circles of different radius and engaging, respectively, toes 20 and 21 of a three-armed lever k^2, the upper arm 22 of which is jointed to the arm *l*, before described. The parts are shown in Fig. 9 in the normal or intermediate position. In place of the steering-engine H any other steering apparatus may be employed. An example of one such apparatus is set forth in my United States Patent No. 785,425, dated March 21, 1905.

The present invention is not limited to the use of electrical means for enabling the gyroscope to control the steering apparatus. Any known or suitable substitute for an electric intermediation may be used. For example, the mechanical tappet device set forth in my United States Patent No. 795,045, dated July 18, 1905, may be applied in connection with the present invention for enabling the gyroscope to control the steering-engine.

I claim as my invention—

1. An automobile torpedo having a gyroscopic steering-gear adapted normally to steer it in a given tactical arc, and having an auxiliary angle-gear adapted to be set to a determined angle to cause the torpedo to steer on an initial arc through such angle preliminary to its steering on its ultimate course by said gyroscopic steering-gear, combined with means for steering the torpedo in a tactical arc of smaller radius than the normal while under control of said angle-gear, whereby the torpedo is more quickly brought to its ultimate course.

2. An automobile torpedo having a gyroscopic steering-gear adapted normally to steer it in a given tactical arc, and having an auxiliary angle-gear adapted to be set to a determined angle to cause the torpedo to steer on an initial arc through such angle preliminary to its steering on its ultimate course by said gyroscopic steering-gear, combined with means for steering the torpedo in a tactical arc of smaller radius than the normal while under control of said angle-gear, and means for terminating the action of said angle-gear upon completing said determined angle, whereby to free the gyroscopic steering-gear and cause it to steer in its normal tactical arc upon said ultimate course.

3. An automobile torpedo having a gyroscopic steering-gear adapted normally to turn the rudder to a prescribed degree to steer the torpedo in a given tactical arc and having an auxiliary angle-gear adapted to be set to a determined angle to cause the torpedo to steer on an initial arc through such angle preliminary to its steering on its ultimate course by said gyroscopic steering-gear, combined with means for turning the rudder to a greater degree than the normal while under control of said angle-gear.

4. An automobile torpedo having a gyroscopic steering-gear adapted normally to turn the rudder to a prescribed degree to steer the torpedo in a given tactical arc and having an auxiliary angle-gear adapted to be set to a determined angle to cause the torpedo to steer on an initial arc through such angle preliminary to its steering on its ultimate course by said gyroscopic steering-gear, combined with means for turning the rudder to a greater degree than the normal while under control of said angle-gear, comprising a lever through which the steering movements are communicated to the rudder, and means for displacing the fulcrum of said lever.

5. An automobile torpedo having a gyroscopic steering-gear adapted normally to steer it in a given tactical arc, and having an auxiliary angle-gear comprising an adjustable turn-table adapted to be set to a determined angle and to cause the torpedo to steer on an initial arc through such angle preliminary to its steering on its ultimate course by said gyroscopic steering-gear, combined with means for steering the torpedo in a tactical arc of smaller radius than the normal while under control of said angle-gear, such means comprising cam-surfaces on said turn-table, and intermediate cooperative mechanism for displacing the rudder to port or starboard upon the displacement of said turn-table from its normal position.

6. An automobile torpedo having a gyroscopic steering-gear adapted normally to steer it in a given tactical arc, and having an auxiliary angle-gear adapted to be set to a determined angle to cause the torpedo to steer on an initial arc through such angle preliminary to its steering on its ultimate course by said gyroscopic steering-gear, combined with means for steering the torpedo in a tactical arc of smaller radius than the normal while under control of said angle-gear, comprising a lever through which movement is communicated to the rudder, cam-surfaces in connection with said angle-gear adapted on the setting thereof to displace the fulcrum of said lever and thereby deflect said rudder, and means acting upon the completion of the initial arc for restoring said fulcrum to its normal position.

In witness whereof I have hereunto signed my name in the presence of two subscribing witnesses.

FRANK M. LEAVITT.

Witnesses:
CHAS. J. ELLSWORTH,
FRED. H. MCGAHIE.