No. 741,683. PATENTED OCT. 20, 1903.

F. M. LEAVITT.

GYROSCOPIC APPARATUS FOR STEERING TORPEDOES.

APPLICATION FILED FEB. 9, 1899. RENEWED FEB. 27, 1903.

NO MODEL. 4 SHEETS—SHEET 1.

FIG. 1.

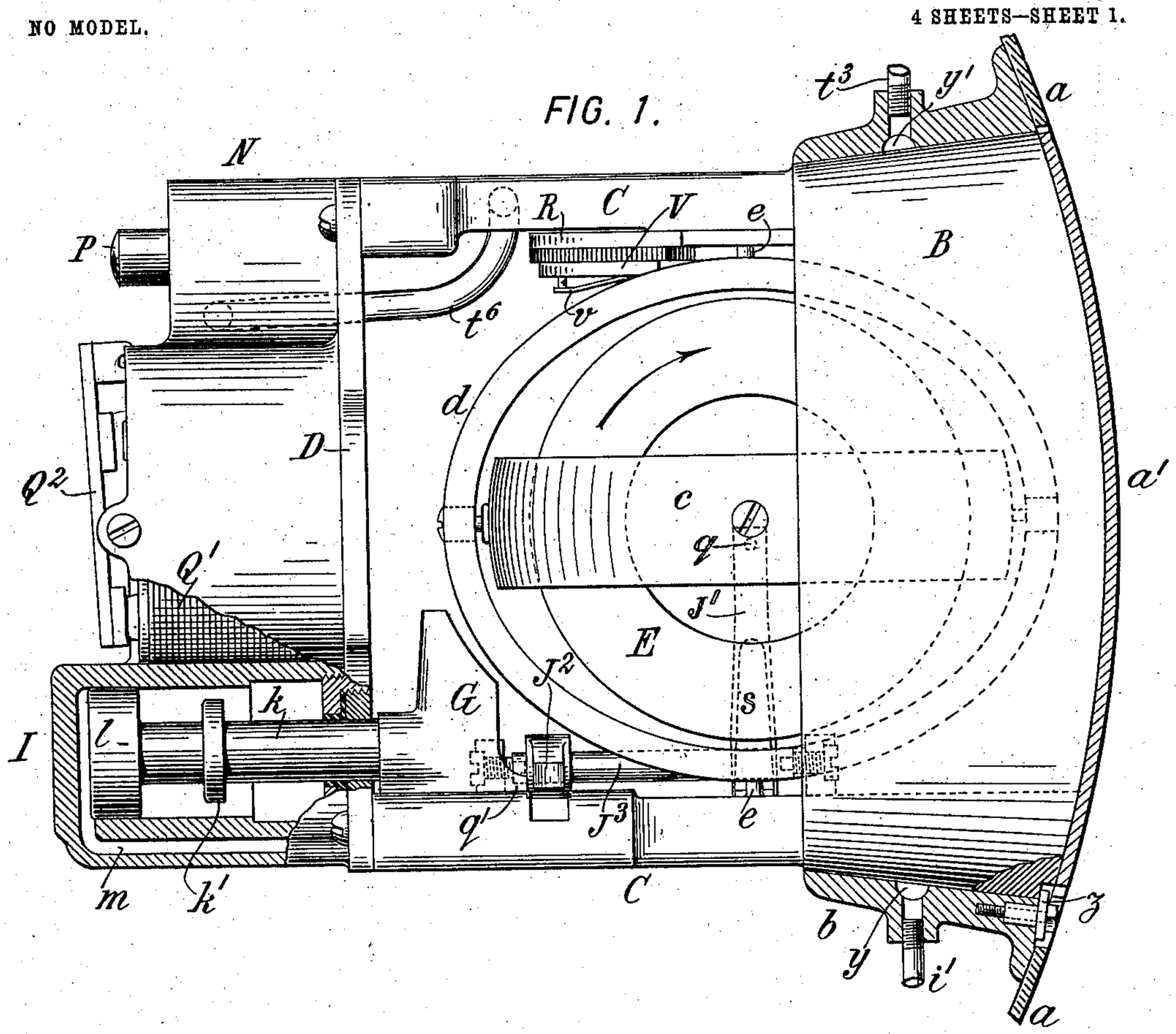
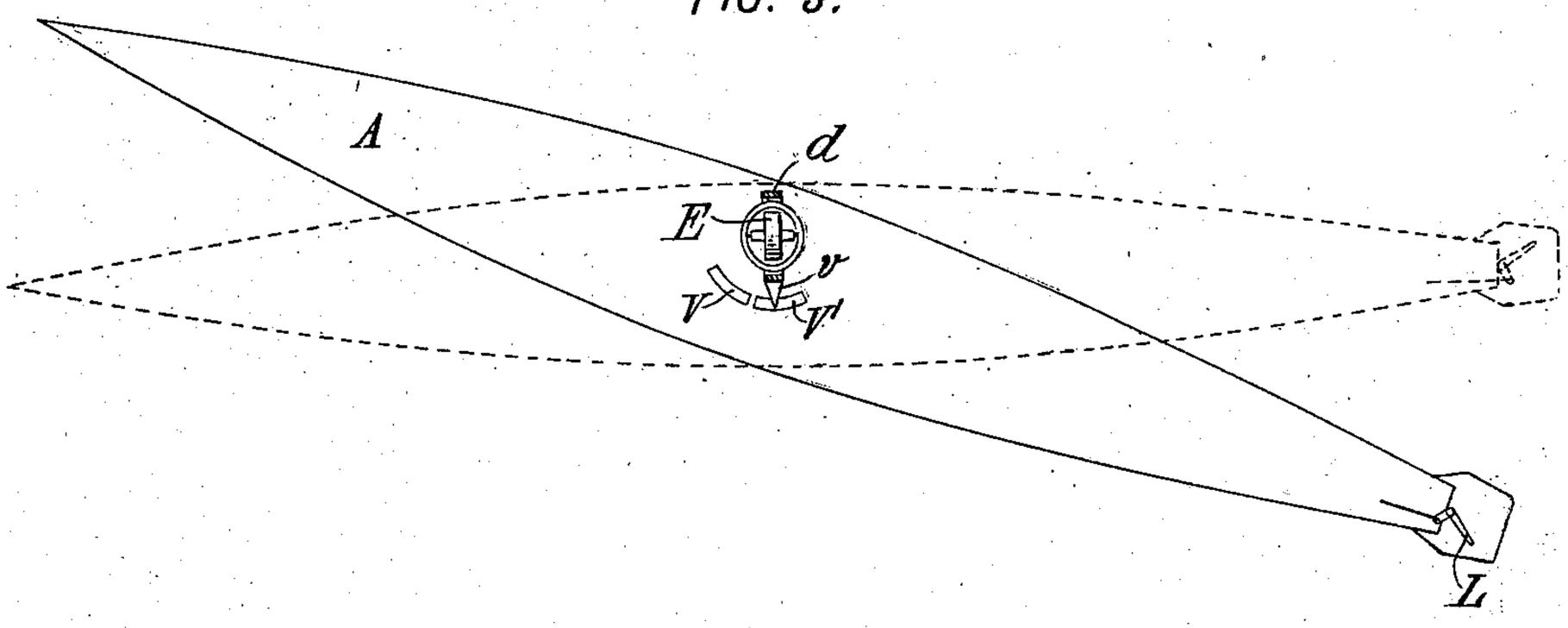


FIG. 5.



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NO MODEL. 4 SHEETS—SHEET 2.

FIG. 2.

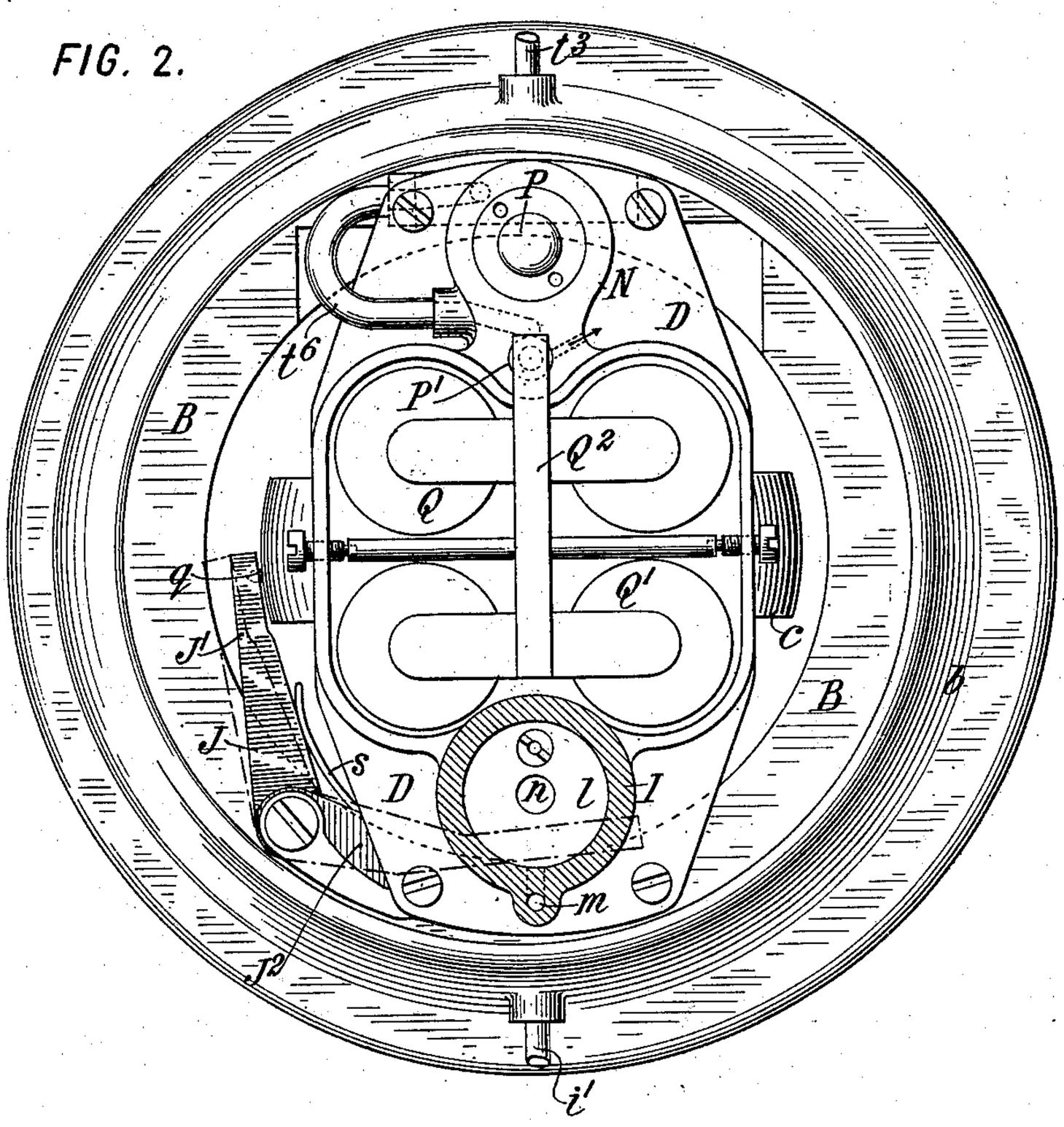


FIG. 6.

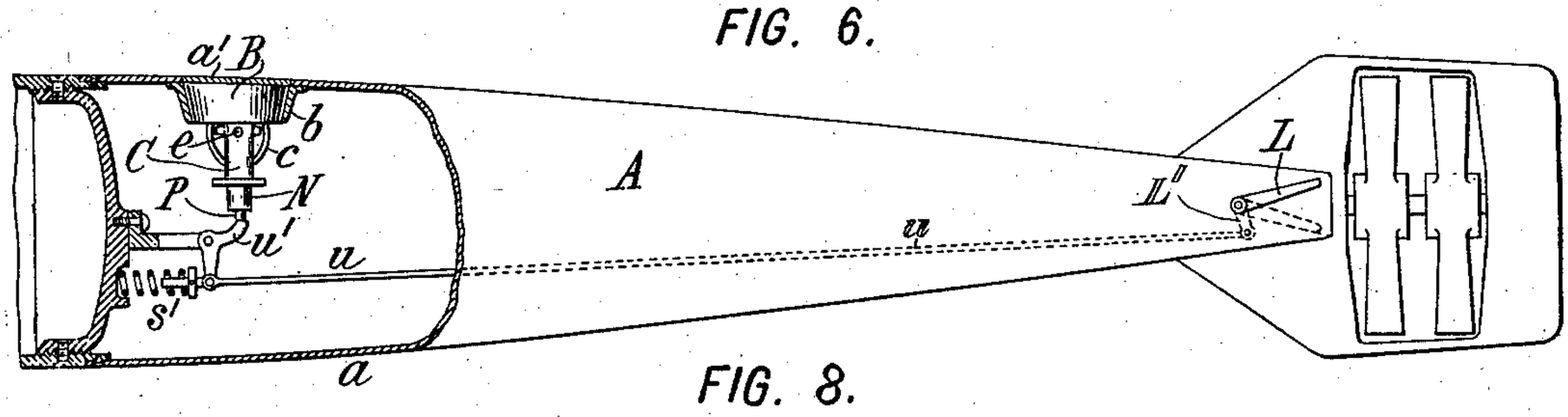
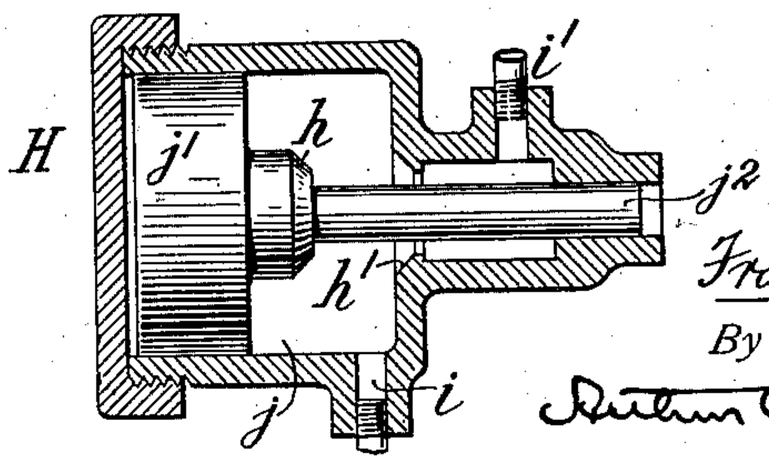


FIG. 8.



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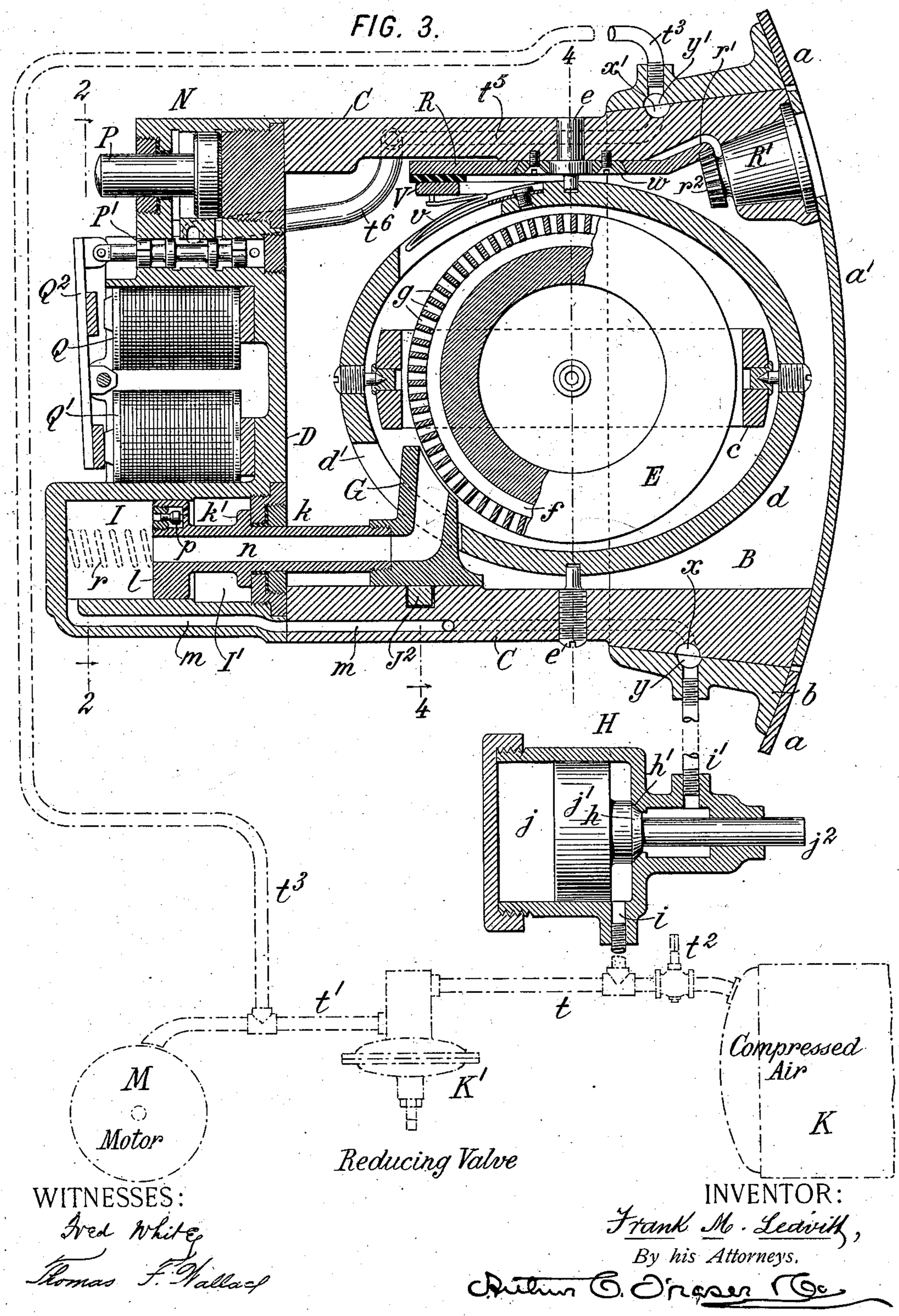
NO MODEL. 4 SHEETS—SHEET 3.

FIG. 3.



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NO MODEL. 4 SHEETS—SHEET 4.

FIG. 4.

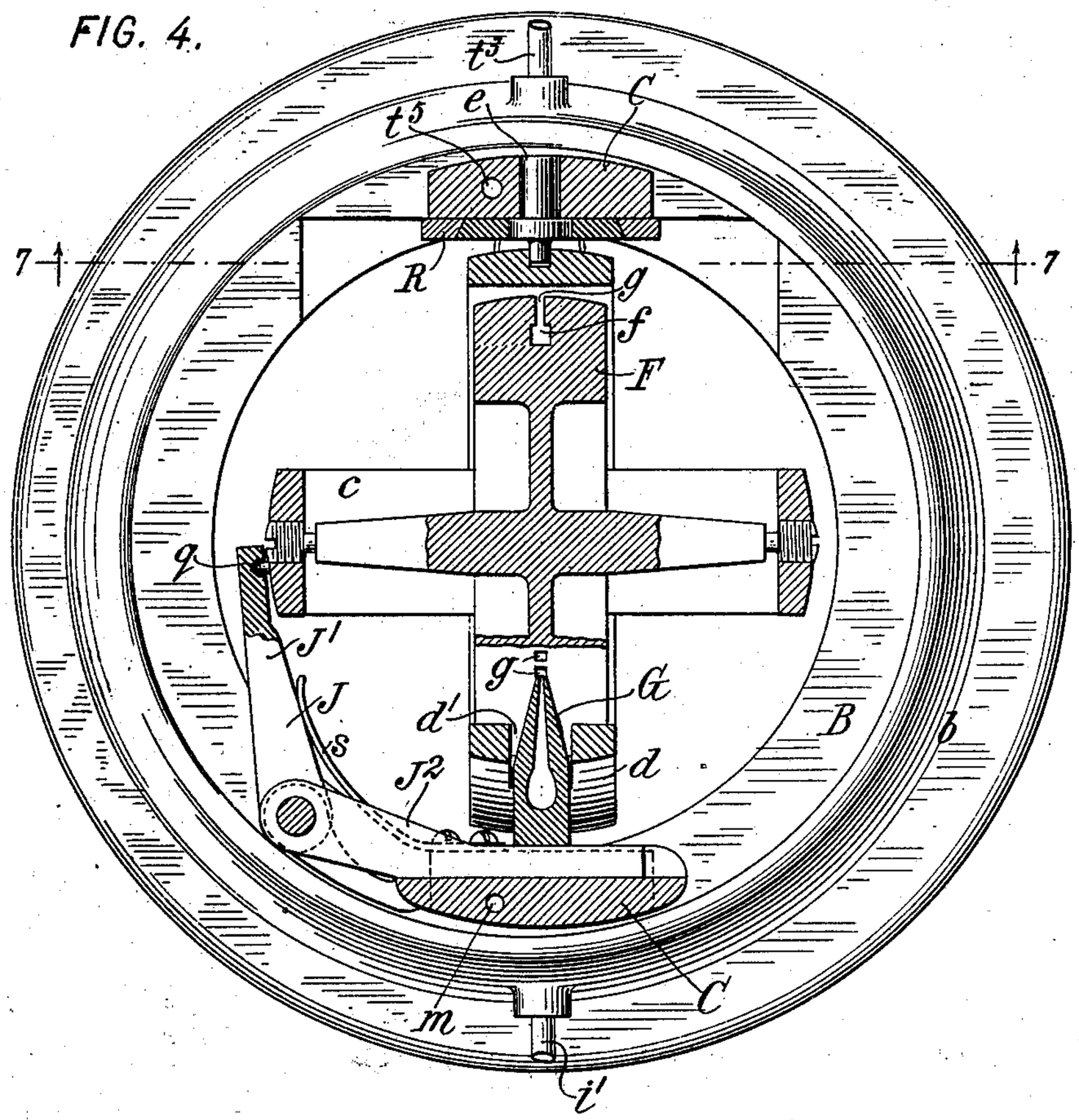
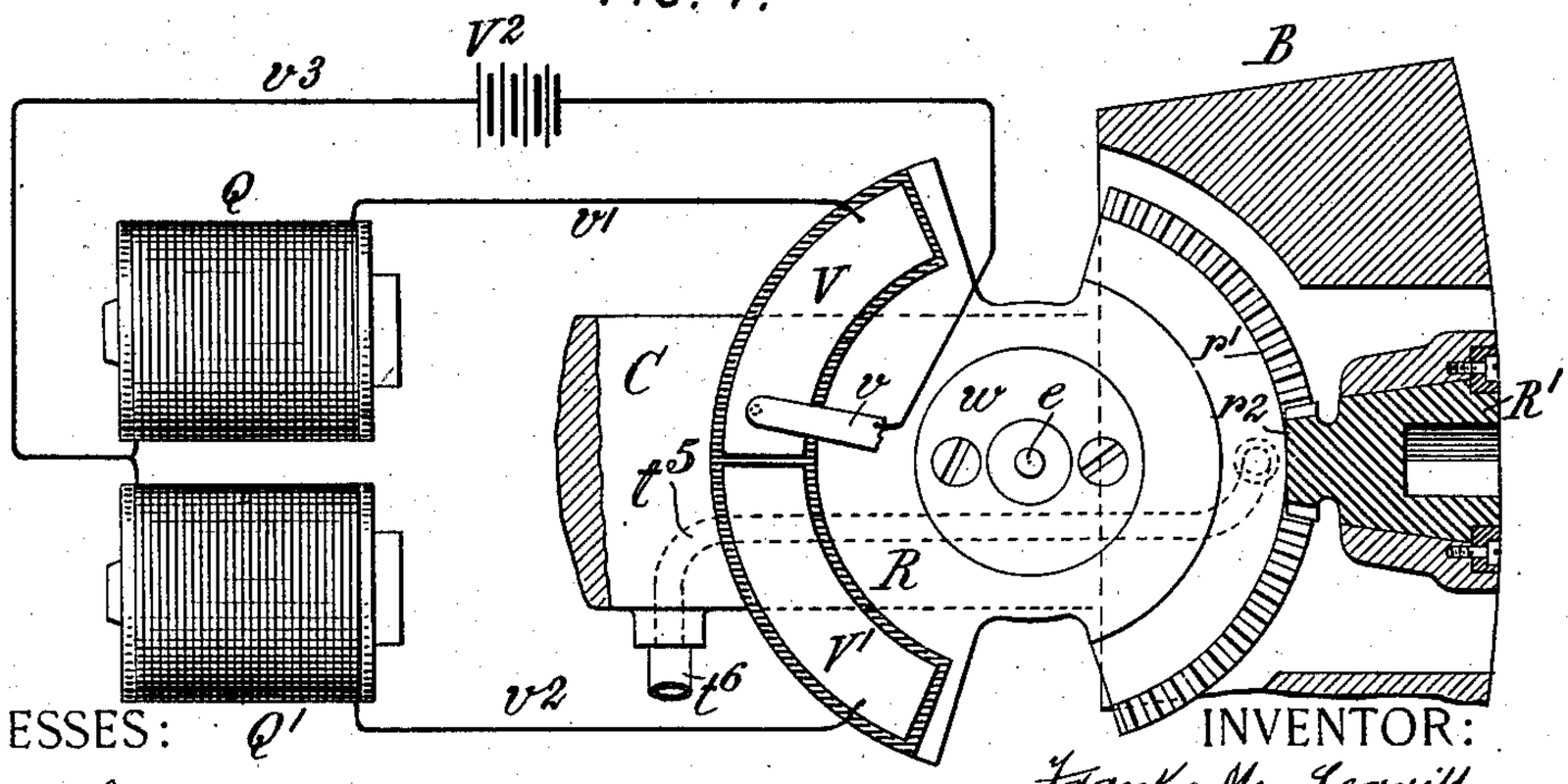


FIG. 7.



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No. 741,683. Patented October 20, 1903.

UNITED STATES PATENT OFFICE.

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GYROSCOPIC APPARATUS FOR STEERING TORPEDOES.

SPECIFICATION forming part of Letters Patent No. 741,683, dated October 20, 1903

Application filed February 9, 1899. Renewed February 27, 1903. Serial No. 145,445. (No model.)

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 Gyroscopic Apparatus for Steering Torpedoes and other Uses, of which the following is a specification.

This invention provides an improved gyroscopic apparatus chiefly applicable for the steering of automobile-torpedoes or other submarine vessels, but also in part applicable for other uses wherever a gyroscopic apparatus is desirable. Hence in its broader features my invention relates to gyroscopic apparatus in general, and more specifically it relates to such apparatus in combination with steering mechanism and to the construction of such apparatus in such manner as to facilitate its application to an automobile-torpedo.

A gyroscope consists of a rotatively-mounted body, as a fly-wheel, so supported, usually through the medium of gimbal-rings, that movement or deflection of the structure whereon it is supported will not be communicated to the axial pivots of the fly-wheel in such manner as to force the latter while revolving out of its normal plane of rotation. Hence a fly-wheel or revolving body so mounted is able to preserve its original plane of rotation notwithstanding the movements of the structure upon which it is carried. This capacity for preserving a fixed plane of rotation renders the gyroscope highly useful for many purposes, notably so for controlling the steering of an automobile-torpedo or other craft which after aiming and launching, is left to itself to direct its own course through the water. A gyroscope is also useful for other purposes, one example of which is to preserve a uniform plane on a ship which is pitching or rolling, or both, in order that such plane may be utilized for certain purposes, such as for determining the instant of firing of guns in order to insure their correct elevation.

Heretofore gyroscopes have been spun or set in rotation by releasing a spring-actuated gearing, or they have been driven in a more continuous manner when necessary by the application of an electromotor.

According to my invention I provide for spinning the gyroscope by the application of fluid-pressure, preferably compressed air. To this end I combine with the fly-wheel of the gyroscope a fluid-pressure motor, preferably a reaction-motor and preferably one wherein the fly-wheel is formed with reaction-surfaces, and a nozzle is provided for directing the jet of fluid under pressure against such surfaces.

My invention provides novel means for discontinuing the action of said motor after the fly-wheel has been brought up to proper speed, also means for locking fast the gimbal-rings or other mounting of the fly-wheel preliminary to spinning it and for unlocking the same upon completing the spinning in order to leave the gyroscope free, such unlocking means being preferably operated by the fluid-pressure which drives the fly-wheel, and I provide also means for admitting fluid-pressure to said motor during a predetermined time sufficient to spin the gyroscope. As applied to the steering of an automobile-torpedo my invention also provides means for communicating the movements of the gyroscope relatively to the plane of direction of the torpedo from the gyroscope or the universal mounting thereof to the steering-rudder and also for enabling the direction in which the torpedo shall be steered to be adjusted at will, and also provides a special construction of gyroscopic apparatus for facilitating its ready application to or removal from the torpedo.

I will proceed to describe my invention with special reference to its application to the steering of a torpedo.

Figure 1 is an elevation of my improved gyroscopic apparatus, partly broken away in section, and showing in section its mounting in the hull or shell of the torpedo. Fig. 2 is an elevation of the inner end of the apparatus, showing also its mounting-ring, the view being partly in section on the line 2 2 in Fig. 3. Fig. 3 is a sectional side view looking in the same direction as Fig. 1 and showing also the pneumatic or fluid pressure ap-

purtenances of the apparatus. Fig. 4 is a view looking in the same direction as Fig. 2 in transverse section on the line 4 4 in Fig. 3. Fig. 5 is a diagram showing in plan a torpedo and showing the gyroscope in position therein. Fig. 6 is a sectional plan of the after part of a torpedo, illustrating the application of my invention thereto. Fig. 7 is in part a fragmentary elevation in section on the plane of the line 7 7 in Fig. 4 and is in part an electrical diagram, showing certain electrical connections. Fig. 8 is a mid-section of the pneumatic time-valve shown in Fig. 3, showing the latter in a different position, it being closed in Fig. 3 and fully open in Fig. 8. Figs. 2, 3, and 4 show the gyroscope set and at rest preparatory to being spun. Fig. 1 shows it in motion directly after being spun. Fig. 8 shows the position of the time-valve intermediate of the positions just described. Figs. 5 and 7 show the apparatus in operation.

Let A in Figs. 5 and 6 designate the hull or body of a torpedo, of which *a* in Fig. 6 is the shell or outer wall. In this shell at one side is formed an opening within which is set a frame or ring *b*. A fragment of the shell *a* and the ring *b* are shown in section in Fig. 1 and also in Fig. 3. Within the conical inner surface of the ring *b* is fitted tightly (preferably by a conical ground joint) a ring B, which constitutes the base upon which the gyroscope apparatus is carried. From this base-ring two parallel arms C C project horizontally, and across their ends is fastened a head or vertical plate D, these arms and plate thus constituting, with the ring B, a fixed framework. Within this framework the gyroscope is mounted. Its fly-wheel E is mounted to turn within a ring *c*, which in turn is pivoted on an axis at right angles to the axis of rotation within a second ring *d*, and the latter is pivoted upon an axis at right angles to the pivotal axis just referred to within the fixed frame already described—that is to say, by means of pivots *e e* therein. The rings *c d* are thus the usual gimbal-rings by which the fly-wheel axis is given a universal mounting with reference to the fixed frame B C D.

It will be understood that the ring B is necessary or desirable only in a torpedo or analogous application and may be substituted by any other suitable base or foot when the apparatus is to be used in other locations, it being only necessary to provide some suitable fixed frame for sustaining the several working parts, the construction of which frame or support may be subject to wide variation, according to circumstances.

For spinning the fly-wheel E, I combine with it a fluid-pressure motor. The construction of this motor may be variously modified, and it may be adapted for being driven by different fluids under a variety of pressures and may be connected in various ways to the fly-wheel during the spinning thereof and may be variously disconnected therefrom upon the completion of the spinning in order to leave the fly-wheel free. I prefer the employment of compressed air or other gaseous fluid and to construct the motor as a reaction-motor, preferably combining rotary impact-faces with a stationary nozzle for discharging the stream of fluid against such faces. I prefer also to construct the impact-faces directly upon the fly-wheel itself, so that the latter constitutes not only the fly-wheel of the gyroscope, but also the rotary member of the motor. To this end I form the fly-wheel with any suitable formation of impact-surfaces, the construction clearly shown in section in Figs. 3 and 4 being suitable, and I provide a nozzle G from which to direct a thin stream of fluid against these impact-surfaces, a suitable construction of nozzle being that clearly shown in section in Figs. 3 and 4. The impact-surfaces are in the construction shown formed by constructing the fly-wheel E with a concentric fluid-passage *f*, from which radiate openings *g g*, extending to the exterior, these openings being arranged in a plane perpendicular to the axis of rotation, which plane coincides with that of the slit or contracted orifice of the nozzle, so that the nozzle directs a stream of fluid against the walls of the openings, which walls constitute the impact-surfaces. The stream of fluid thus directed against these surfaces on rebounding therefrom flows through the openings into the inner channel *f*, through which it circulates, and thereby distributes itself among the numerous openings through which it finds free escape.

By turning compressed air through the nozzle G for a brief interval—say one second or less—the fly-wheel can by this means be spun up to the requisite velocity for storing sufficient power to keep the gyroscope running for a considerable time. In practice in applying my invention to an automobile-torpedo I turn on an air-pressure of approximately thirteen hundred pounds per square inch for one-half second, whereby the fly-wheel is spun up to a speed of approximately eight thousand or nine thousand revolutions per minute, or sufficient to keep it spinning for over ten minutes.

It is necessary to provide means for controlling the flow of compressed fluid to the motor in order to cut off the flow of fluid after a predetermined time—that is to say, after such time as is sufficient to spin up the fly-wheel to the requisite speed. This time will of course vary according to the proportions adopted in any case and also according to the fluid-pressure used and the length of time during which the gyroscope is to remain active. To this end I provide for controlling the supply of compressed air or other fluid a device which I will call a "time-valve." This time-valve, which as a whole is lettered H, is shown in section in Figs. 3 and 8. It consists of a stop-valve *h*, adapted to close against a seat *h'*, and thereby cut off communication between the compressed-air inlet *i* and the

outlet i', which are on opposite sides of said seat, and of means for operating said valve, comprising a cylinder or chamber j and a piston j', working therein and connected to the valve h. The normal or starting position of the valve is closed, as shown in Fig. 3. Upon turning on fluid-pressure the latter entering through i acts against the piston j' to force the latter to the left, to the position shown in Fig. 8, thereby opening the valve h and permitting the air to flow through the seat h' and out by the outlet i' to the nozzle G. The body of air originally imprisoned in the chamber j to the left of the piston serves as a cushion to check its opening movement. The piston j' is not a tight fit with its cylinder, and consequently the compressed air can leak past it and act against its left side or face. The piston is of unbalanced area by reason of being provided with a stem j^2, which passes out through the valve-shell, as shown, so that when the valve is open, as in Fig. 8, the piston J′ receives the full fluid-pressure against all of its right-hand side except the area of the stem j^2, which receives only the pressure of the external atmosphere, while the fluid-pressure as fast as it can leak past the piston acts against the full area of the left side thereof, and consequently acts effectively against an area equal to that of the cross-section of the stem, so that the high pressure acting against this differential area forces the piston toward the right with a speed proportionate to the extent of leakage or looseness of fit of the piston. This movement continues until the valve h is again seated, whereupon the flow is shut off, and so long as the fluid-pressure remains turned on the valve continues pressed to its seat thereby. This time-valve thus opens instantly upon the turning on of fluid-pressure and closes progressively at a rate which varies according to the looseness of fit of the piston. By a suitable proportioning of this looseness of fit the valve may be caused to close in any predetermined time desired. This means for controlling the duration of flow is extremely simple and operates with great precision.

It is obviously necessary that the flexible mounting of the fly-wheel should be held rigid during the operation of spinning the fly-wheel up to speed. To this end some suitable means must be provided for locking fast the gimbal-rings c d. Such locking device must be unlocked after spinning up the fly-wheel in order to leave the gyroscope free. In order to comply with these conditions, I have devised a locking and unlocking means, which I will now describe. In the ring d I form a slot d', Figs. 3 and 4, through which the nozzle G projects in order that its tip may come close against the reaction-surfaces of the fly-wheel. Hence the nozzle when in this position, as shown in Figs. 3 and 4, by standing in this slot prevents turning of the ring d. The nozzle and slot may be made a close fit, so that the nozzle serves as the lock for the ring, though I prefer to make them a loose fit; but in either case in order to free the ring the nozzle is caused to move backward out of the notch d' to the position shown in Fig. 1. This movement I effect automatically by means of the fluid-pressure to such effect that instantly upon the cutting off of the stream of compressed air by the time-valve H the nozzle G is caused to execute its retreating movement. To this end the nozzle G is mounted upon a tubular piston-rod k, which carries a piston or plunger l, which moves in a cylinder I. The compressed air enters the outer end of this cylinder through a duct m and flows therefrom through the bore or duct n within the piston-rod to the nozzle G. The piston l in the position shown in Fig. 3 divides the cylinder I, thus forming a chamber I′ beyond the piston, into which the compressed air flows through a small hole in the piston, which is controlled by a check-valve p. Hence the instant after the compressed air is turned on the chamber I′ becomes filled with compressed air at a high pressure and remains so until the time-valve H cuts off the flow of air, whereupon the air remaining in the ducts and in cylinder I quickly escapes through the nozzle G, leaving a charge of air at high pressure stored in the chamber I′. This air cannot return into the cylinder I past the check-valve p, which closes in this direction. Hence the expansion of the confined air in I′ forces the piston to the left and moves with it bodily the rod k and nozzle G to the position shown in Fig. 1. A cupped packing around the rod forms a stuffing-box for preventing escape of air outwardly. In the normal position an annular collar or flange k' abuts against the inner end or head of the cylinder, as shown, and forms a stop. The retreating movement of the nozzle G thus accomplishes two results: First, it frees the ring d, and, second, it removes the nozzle itself beyond the fly-wheel E, and thereby disconnects the fluid-pressure motor as soon as it has completed its work of spinning up the fly-wheel.

For locking the rings c and d to hold them immovable while spinning up the fly-wheel I provide a locking-lever J, one arm, J′, of which has a recess which receives a pin q on the ring c, preferably near or in the axis of rotation of the fly-wheel, while the other arm, J^2, extends beneath the nozzle G, as best shown in Figs. 3 and 4. A spring s is suitably arranged to press against the lever J, tending to displace it and release the pin q; but this is prevented by the arm J^2 being held back beneath the nozzle G. When, however, the nozzle G is displaced to the position shown in Fig. 1, the arm J^2 is thereby released and swings out under the impulse of the spring, the lever J moving to the position shown in dotted lines in Fig. 2 and releasing the pin q, so that the ring c becomes unlocked simultaneously with the freeing of the ring d. The movement of the arm J^2 just described car-

ries it beyond the end of the nozzle G, as shown in Fig. 1, and hence insures against any possible rebound or return movement of the nozzle G, since any such movement would bring a prolongation or toe q' thereon against the arm J^2 before the nozzle could move into the path of the ring d. The arms J' J^2 are both fixed upon an oscillatory spindle J^3, suitably pivoted upon arms or brackets projecting from the frame C. Other specific means for locking the rings may be substituted to be worked, preferably, by the fluid-pressure to such effect that upon the cessation of the jet or blast from the nozzle the rings shall be instantly unlocked.

Before the gyroscopic apparatus is operated—that is to say, before compressed air is turned on—it is necessary to set the apparatus. When used in a torpedo, the base-ring B and the parts carried thereby are removed from the frame b, whereby access is had to all the parts. The rings c and d are first brought into position, whereupon the spring-pressed lever J is moved to engage it with the pin q. This brings the arm J^2 down out of the path of the nozzle G, whereupon this nozzle is pushed into the slot d' in the outer ring until it reaches its proper position close against the fly-wheel, as shown in Fig. 3, with the flange k' against the head of the cylinder I, as there shown. The apparatus may then be replaced in position in the ring b. It may be advantageous to introduce a spring for pressing the nozzle and piston to the right in order to hold the parts firmly in this position before operation, such spring being indicated in dotted lines at r in Fig. 3.

I have indicated in Fig. 3 in somewhat diagrammatic manner in dotted lines the pneumatic apparatus employed in an automobile torpedo in order to illustrate the connection therewith of my gyroscopic apparatus. K is the usual flask or pressure-cylinder containing compressed air at high pressure, from which leads a pipe t, which extends to a pressure-reducing valve K' and from which extends a pipe t', which leads to the motor or engine M for driving the screws for propelling the topedo, which motor M may of course be the usual reciprocating multicylinder-engine or may be any other suitable motor, that indicated in the diagram being a compressed-air turbine. In the pipe t is a valve t^2, which is the starting-valve, being opened automatically during the operation of launching the torpedo in the manner well understood. Between this valve and the reducer K' a branch pipe conducts the air under full pressure to the inlet i of the valve H. From the reduced-pressure pipe t' a branch pipe t^3 leads for conveying air under lower pressure to the steering apparatus, which will be described. The air for spinning the gyroscope is taken from the high-pressure pipe t in order that the air at maximum pressure may be utilized for spinning up the gyroscope instantly in order that the gyroscope may be rendered active before the torpedo leaves the launching-tube, and consequently while its direction, and hence that of the rotative axis of the fly-wheel, is definitely fixed by the aiming of the launching-tube.

I will now proceed to describe how I apply my gyroscopic apparatus for controlling the steering of a torpedo or other analogous craft.

Referring to Fig. 6, which shows the torpedo in plan, L is the steering-rudder thereof, which is moved between the positions shown in full lines and in dotted lines by means of an internal arm L', fixed on the rudder-shaft within the hull and connected by a rod u to the gyroscopically-controlled steering mechanism. In the particular construction shown in Fig. 6 this rod u receives at one end the pressure of a spring s' strong enough to throw the rudder to the position shown in full lines, and for throwing the rudder to the dotted-line position a pneumatic engine N, comprising a cylinder and piston, is provided, the piston acting through an elbow-lever u' against the rod u to compress the spring. Other arrangements may of course be substituted; but the means thus shown serves the purpose well. Preferably I mount the pneumatic engine N on the cross-head or plate D by constructing the engine-cylinder as an integral part of this cross-head casting. The piston-rod or plunger P projects out through a stuffing-box, as shown, so that when the apparatus is in place it comes against one arm of the elbow-lever u' in the manner shown in Fig. 6. The pneumatic engine is controlled by a balanced valve P', (clearly shown in Fig. 3,) by which compressed air entering through a pipe t^6 is admitted to either side of the piston, while the exhaust from the opposite side of the piston is permitted to escape to the atmosphere. As this is an ordinary type of pneumatic engine, it requires no special description. The valve P' is operated from the gyroscope in any suitable manner. It might of course be directly connected to the outer ring d of the gyroscope, so that the oscillations of this ring corresponding to changes of direction of the torpedo-hull would act directly against the valve to shift it; but although the valve is balanced, and hence operates with the minimum of resistance, yet such direct connection would impose an amount of resistance to the free oscillation of the ring as would to some extent impair the effectiveness or exactness of operation of the apparatus, and hence I prefer to provide for such connection between the gyroscope-ring and the valve as shall oppose the minimum of retardation to the movements of the gyroscope. To this end I provide for operating the valve electromagnetically, under control of a circuit-closer which is operated by the gyroscope-ring and which circuit-closer can be so delicately adjusted as to impose only the most minute resistance upon the movements of the ring. Accordingly I arrange two electromagnets Q and Q' to act in opposition to each

other upon armatures carried by a lever Q^3, which is connected to the valve P'. Preferably I mount the magnets Q Q' fixedly upon the cross-head D in manner shown and fix their armatures upon opposite arms of the lever; but other arrangements may be substituted to equal advantage. The circuit-closer shown consists of a light spring-arm v, carried by the ring d, as shown in Fig. 3, the free end of this spring terminating in a platinum point, which as the ring oscillates is moved over arc-shaped contact-segments V V', which are best shown in Fig. 7. These segments are insulated and are connected by circuit wires or conductors $v' v^2$, respectively, as shown in Fig. 7, to the windings of the respective magnets, the opposite terminals of which windings are connected in a circuit v^3, which includes an electric battery V^2 (or a dynamo) and terminates in a connection with the spring v, which connection may be made through the frame, pivots, and ring d. The operation of this connection will be apparent on examining Figs. 5 and 7. In Fig. 5 the dotted lines show the position of the torpedo-boat in following its true course, the plane of rotation of the fly-wheel of the gyroscope being in this instance perpendicular to a vertical plane coinciding with the longitudinal axis of the torpedo. Any deflection of the torpedo from its true course—as, for example, a deflection to the position shown in full lines in Fig. 5—does not alter the plane of rotation of the gyroscope, but simply moves with reference thereto the circuit-closing segments V V'. As soon as the tip of the spring v passes thus onto one of the segments an electric current passes through the corresponding branch circuit v' or v^2 and energizes the corresponding magnet Q or Q', Fig. 7, which, acting through the lever Q^2, Fig. 3, throws over the valve to the opposite position, and consequently admits compressed air from the pipe t^6 to the opposite side of the piston of the pneumatic engine N, thereby causing movement of the plunger P thereof in such direction as to throw the rudder L, Fig. 6, to the contrary position—that is, to such position as will cause the hull of the torpedo to be steered back into its normal course, being the rudder position shown in full lines at L in Fig. 5. It results from this that the torpedo is steered back until it reaches its normal course, at which instant the tip of the spring v, Fig. 7, passes across the insulating-gap between the two sectors, and as the rudder position remains fixed, so that the torpedo-hull consequently steers beyond its normal course, the spring passes onto the other segment—as shown, for example, in Fig. 7—thereby cutting off the current from the magnet previously energized and directing it into the other magnet, which again throws over the valve P' and again reverses the pneumatic engine, thus throwing the rudder to the opposite position and steering the torpedo in the contrary direction back toward its normal course. It results from this arrangement that the torpedo follows a sinuous path, steering alternately to right and left of its true course and repeatedly crossing such true course. In practice, however, the rudder is thrown from one side to the other upon a very slight deflection of the torpedo from its true course, so that its sinuous movements constitute but a slight departure from a straight line constituting the true theoretical course of the craft. The gyroscope should of course be proportioned to continue spinning at suitable speed for a period sufficiently longer than the total duration of run of the torpedo.

In case the launching-tube is aimed in the direction in which it is desired that the torpedo shall travel the segments V V' should be so arranged relatively to the initial plane of the gyroscope that the point of the spring v shall at the instant of launching rest upon the insulating-space between the segments. It is, however, sometimes desirable to launch the torpedo in a different direction from its destined course—as, for example, in launching it from a torpedo-boat in rapid motion it may be desirable to launch the torpedo from the bow or stern and cause the torpedo to assume subsequently the desired course, which may, for example, be athwart ships or ninety degrees from the direction in which it is launched. To enable this result to be accomplished, I mount the segments V V' on an angularly-adjustable base or disk and provide means for enabling this disk to be adjusted to any desired angle. The disk referred to is lettered R, being best shown in Figs. 3 and 7. It is pivotally mounted on the arm C concentric with the pivot e by means of an annular pivotal plate w. For turning the disk R from the exterior I form it with a toothed segment r', engaged by a pinion r^2, formed on a rotatively-mounted spindle R', which is fitted tightly and preferably by a conical ground joint in a socket formed in the ring V, as shown in Figs. 3 and 7. The spindle R' has a square socket, in which a key may be inserted for turning it. The spindle and disk turn with such friction that they will remain securely in any position to which they are turned. The ratio of the pinion and sector being known, it is only necessary to turn the spindle R' through as many degrees as divided by this ratio will equal the number of degrees that it is desired to displace the disk R, being the same number of degrees through which the torpedo is destined to swing after launching and before reaching its destined course.

Inasmuch as my gyroscopic apparatus includes two pneumatic engines—namely, the fluid-pressure motor and its appurtenances for spinning up the fly-wheel and the pneumatic steering-engine N—it is desirable to provide some convenient means for effecting the necessary connections between these parts, which are removable with ring B and the pipes conveying pneumatic pressure with-

in the shell of the torpedo. Obviously it would be very difficult to provide for making such connections by means of couplings or screw-joints such as are usually employed. Accordingly I provide for making the necessary pneumatic connections through the ground joint uniting the base-ring B to the frame or ring *b*, in which it fits. To this end I form the base-ring *b* at suitable positions with a connection for receiving the outlet-pipe *i'* from the time-valve, terminating in an inner groove or channel *y*, Fig. 3, and with a connection for receiving the low-pressure branch pipe t^3, terminating in an internal groove or channel *y'*, and I form the ring B with external grooves or channels *x* and *x'*, which when the ring is in position coincide with the said channels *y* and *y'*, respectively. From the groove or channel *x* a duct or passage *m* is formed through the ring B and arm C, leading to the cylinder I. From the channel *x* a duct or passage t^5 is formed through the material of the ring and upper arm C, following the course indicated in dotted lines at t^5 in Fig. 7 and communicating with the pipe t^6, by which the compressed air under reduced pressure is led to the inlet-port of the valve E' of the pneumatic engine N. The conical surfaces of the ring B and frame *b* are ground to a tight fit, and when the ring is in position it is held by any suitable means—as, for example, by two or more fastening-screws, of which one is shown at *z* in Fig. 1. By removing these screws the ring B may be removed, thereby disconnecting the gyroscope and all its appurtenances from the hull of the torpedo. The outer side of the ring B is closed by a shell *a'*, which when in place forms a continuation of the main shell *a* of the torpedo.

In the adaptation of my invention to a torpedo its preferred form, as shown, is advantageous in that the gyroscope and its motor and also the steering-engine and all intermediate and accessory parts are compactly but accessibly mounted upon the one support in such manner that the whole can be conveniently taken out of the torpedo-hull, and hence can be readily inspected or adjusted. Also the removal of these parts leaves the ring or frame *b* as a large hand-hole through which access can be had to the parts through which the steering movements are communicated to the rudder.

My invention in its broader aspects provides a very simple mechanism for effecting automatically the spinning up and unlocking of a gyroscope, utilizing therefor a source of energy many times greater than can be practically attained by either a spring-motor or an electromotor. My invention thus attains a simplification of the accessories of the gyroscope and at the same time adds greatly to the effectiveness of the gyroscopic apparatus.

It must not be inferred from the particularity of detail with which I have described the preferred form of my apparatus that my invention is by any means limited to the details thus set forth, since, in fact, my invention in its broader aspects is susceptible of a wide degree of modification and may be availed of by means of a great variety of mechanical details and accessory or intermediary devices. For example, the fluid-pressure motor may be any other known type of reaction-motor. Also circuit-closer V V' *v* may be substituted by any other suitable construction of circuit-closer. Also instead of using two magnets Q Q' to act against each other a single magnet may be provided acting against any suitable opposing or retractile force. Also it is within my invention to dispense entirely with electromagnetic means for connecting the gyroscope to the valve of the pneumatic steering-engine, since other means for controlling this engine from the gyroscope may be substituted if sufficiently delicate in operation to avoid interposing any serious resistance to the movements of the gyroscope. It is also apparent that in lieu of a pneumatic engine any other means controllable by the delicate action of the gyroscope and capable of transmitting the requisite power to the steering-rudder or other thing to be operated may be substituted. My invention may be otherwise modified in many ways or may be availed of in part only, according to the particular circumstances under which it is applied in any special case and depending upon the particular service it is there destined to perform.

I claim as my invention the following-defined novel features, substantially as hereinbefore specified, namely:

1. A gyroscope having a fluid-pressure reaction-motor for spinning it, combined with means for controlling the admission of fluid-pressure to said motor during a predetermined time sufficient to spin the gyroscope, said means being adapted to thereupon cut off the flow of fluid thereto.

2. A gyroscope having a fluid-pressure motor for spinning it, combined with a source of pressure, and a valve adapted to admit fluid-pressure to said motor during a predetermined time sufficient to spin the gyroscope, and thereupon to cut off the flow of fluid thereto.

3. A gyroscope having a fluid-pressure motor for spinning it, combined with means for admitting fluid-pressure to said motor during a predetermined time sufficient to spin the gyroscope, consisting of a valve and its actuating-piston, the latter presenting its full area for closing the valve and a diminished area for opening it, and means for admitting a restricted flow or leakage to the back of said piston for closing the valve.

4. A gyroscope comprising a fly-wheel mounted in gimbal-rings, having a fluid-pressure motor for spinning it, combined with means for controlling the admission of fluid-pressure to said motor, and means actuated

by the fluid-pressure for disconnecting said motor upon the cessation of the flow of fluid to said motor.

5. A gyroscope having in combination reaction-surfaces, a nozzle for directing fluid under pressure against said surfaces for spinning the gyroscope, and means for automatically withdrawing said nozzle after spinning to leave the gyroscope free.

6. A gyroscope comprising a fly-wheel mounted in gimbal-rings, said fly-wheel formed with reaction-surfaces, combined with a nozzle for directing fluid against said surfaces for spinning the wheel, one of said rings formed with a slot through which the nozzle enters, whereby when the nozzle is in place it locks said ring, and means for withdrawing said nozzle from said slot after spinning to unlock said ring.

7. A gyroscope comprising a fly-wheel mounted in gimbal-rings, having a fluid-pressure motor for spinning it, combined with means for controlling the admission of fluid-pressure to said motor, means for locking fast said rings during spinning, and means for unlocking said rings upon the cessation of the flow of fluid to the motor.

8. A gyroscope comprising a fly-wheel mounted in gimbal-rings, having a fluid-pressure motor for spinning it, combined with means for locking fast said rings during spinning, comprising a spring-pressed lever engaging the rings and tending to disengage itself therefrom, and means for normally holding said locking-lever in the locking position, adapted to be displaced to free said lever upon the cessation of the fluid-pressure feeding said motor.

9. A gyroscope comprising a fly-wheel mounted in gimbal-rings, combined with a fluid-pressure motor for spinning it, means actuated by the fluid-pressure for withdrawing the nozzle of said motor upon the cessation of the flow of fluid thereto, and a locking device for holding said rings during spinning, tending to unlock and restrained therefrom by engagement with said nozzle, and freed to unlock the rings by the withdrawal of said nozzle.

10. A gyroscope comprising a fly-wheel mounted in gimbal-rings, said fly-wheel formed with reaction-surfaces, combined with a nozzle for directing fluid under pressure against said surfaces for spinning it, and a cylinder and piston, said cylinder communicating with the same source of fluid-pressure as said nozzle, and the piston movable therein connected to said nozzle, whereby its movement under impulse of the fluid-pressure withdraws said nozzle from the fly-wheel.

11. A gyroscope comprising a fly-wheel mounted in gimbal-rings, said fly-wheel formed with reaction-surfaces, combined with a nozzle for directing fluid under pressure against said surfaces for spinning it, and a cylinder and piston, said cylinder communicating with the same source of fluid-pressure as said nozzle, and the piston movable therein connected to said nozzle for communicating movement thereto, having a duct for permitting compressed air to pass said piston and accumulate a pressure upon the opposite side thereof, whereby upon the cessation of the flow of fluid under pressure to said nozzle, the accumulated pressure beyond said piston acts to displace said piston and thereby withdraw the nozzle.

12. A gyroscope comprising a fly-wheel mounted in gimbal-rings, said fly-wheel formed with reaction-surfaces combined with a nozzle for directing fluid under pressure against said surfaces for spinning it, and a cylinder and piston, said cylinder communicating with the same source of fluid-pressure as said nozzle, and the piston movable therein connected to said nozzle for communicating movement thereto, having a duct for permitting compressed air to pass said piston and accumulate a pressure upon the opposite side thereof, and a valve in said duct for checking the return flow of fluid therethrough, whereby upon the cessation of the flow of fluid under pressure to said nozzle the accumulated pressure beyond said piston acts to displace said piston and thereby withdraw the nozzle.

13. A gyroscope comprising a fly-wheel mounted in gimbal-rings, said fly-wheel formed with reaction-surfaces combined with a nozzle G movable toward and from said fly-wheel, a cylinder I, a piston *l* movable therein, a tubular piston-rod *k* connecting said piston to said nozzle, a passage admitting fluid-pressure to said cylinder, and a duct permitting fluid-pressure to flow past said piston to accumulate in the opposite end of said cylinder, to the effect set forth.

14. A gyroscope comprising a fly-wheel mounted in gimbal-rings, a spring-pressed locking-lever J for locking fast said rings during spinning, a fluid-pressure motor for spinning the fly-wheel, a cylinder and piston connected to the same source of fluid-pressure, and a movable part for holding said lever in its locking position, connected to said piston to be withdrawn to release said lever upon the cessation of the flow of fluid under pressure to said motor, whereby the gimbal-rings are unlocked automatically after spinning.

15. A gyroscope comprising a fly-wheel mounted in gimbal-rings, a spring-pressed locking-lever J for locking fast said rings during spinning, the nozzle G of a fluid-pressure motor for spinning said fly-wheel, a cylinder and piston connected to the same source of fluid-pressure to move the piston upon the cessation thereof, and said piston connected to said nozzle for communicating a retreating movement to the latter, and said nozzle arranged in its operative position to hold said locking-lever in its locking position, and when retracted to free said lever and thereby cause the unlocking of the rings after spinning.

16. A gyroscope combined with a fluid-pressure motor for spinning it, an electric circuit

controlled by said gyroscope, and a circuit-closer comprising a stationary conducting-segment, and a contact-arm carried by the gyroscope and movable over and beyond said segment.

17. A gyroscope combined with an electric circuit controlled thereby, a circuit-closer comprising a normally stationary segment, and a contact-arm carried by the gyroscope and movable over said segment, and an adjustable part carrying said segment movable around the pivotal axis of the gyroscope, whereby the adjustment of said part to different angles determines the point in the oscillation of the gyroscope at which the circuit shall be closed or broken.

18. A gyroscope combined with an electric circuit controlled thereby, a circuit-closer comprising a normally stationary segment, and a contact-arm carried by the gyroscope and movable over said segment, an adjustable plate or disk carrying said segment, formed with a segmental gear and a pinion meshing therewith, whereby to adjust said plate or disk to varying angles.

19. In an automobile torpedo or analogous craft, the combination of a source of compressed fluid thereon, a steering-rudder, a gyroscope, a fluid-pressure motor for spinning the latter, a valve for admitting fluid-pressure from said source to said motor for a predetermined time sufficient to spin the gyroscope, a fluid-pressure engine connected to and operating said rudder, fed with pressure from said source, and connections between the gyroscope and the valve of said engine, whereby the latter is controlled by the gyroscope.

20. In an automobile torpedo or analogous craft, the combination with the hull thereof having an opening and an annular frame encircling said opening, of a removable ring fitting said frame, a gyroscope carried thereby, a fluid-pressure motor carried thereby for spinning said gyroscope, a reservoir of fluid under pressure carried in said hull, and a valved passage connecting from said reservoir to said motor.

21. In an automobile torpedo or analogous craft, the combination with the hull thereof having an opening and an annular frame encircling said opening, of a removable ring fitting said frame, a gyroscope carried thereby, a fluid-pressure motor carried thereby for spinning said gyroscope, a reservoir of fluid under pressure carried in said hull, and a valved passage leading from said reservoir through the joint between said annular frame and ring to said motor, whereby the connection of the source of fluid-pressure to the motor is made in the act of fitting in said ring.

22. In an automobile torpedo or analogous craft, the combination with the hull thereof having an opening and an annular frame encircling said opening, of a removable ring fitting said frame, a gyroscope carried thereby, a fluid-pressure motor carried thereby for spinning said gyroscope, a fluid-pressure engine also carried by said ring, and a connection between the gyroscope and the valve of said engine for controlling the latter, a reservoir of fluid-pressure carried in said hull, and a valved passage leading from said reservoir and having branches connected respectively with said motor and said engine, said passage leading through the joint between said annular frame and ring, whereby the fitting of said ring in place effects the connection of said motor and engine to the source of their supply.

23. In an automobile torpedo or analogous craft, the combination with the hull thereof having an opening and an annular frame encircling said opening, and having a conical inner face, of a removable ring having a conical outer face fitting into said frame with a ground joint, a gyroscope, and a fluid-pressure motor for spinning it, carried by said ring, a reservoir of fluid under pressure in said hull, and a passage leading from said reservoir to and through said annular frame to the joint-face thereof, and said ring formed with a passage leading from its joint-face in coincidence with and forming a continuation of said first-named passage, and leading to said motor.

24. In an automobile torpedo or analogous craft, the combination with the hull thereof having an opening and an annular frame encircling said opening, of a removable ring fitting said frame, a gyroscope carried thereby, a fluid-pressure motor carried thereby for spinning said gyroscope, a pneumatic engine to be controlled by said gyroscope, also carried by said ring, an electromagnetic device operating the valve of said engine, and a circuit-closer controlling said electromagnetic device and operated by said gyroscope, both carried by said ring, whereby the removal of the ring removes together the gyroscope, its motor, the engine controlled thereby, and the intervening connection, without disturbance thereof.

25. In an automobile torpedo or analogous craft, the combination with the hull thereof having an opening and an annular frame encircling said opening, of a removable ring fitting said frame, a gyroscope carried thereby, a circuit-closer carried thereby and comprising a normally stationary conducting-segment, and a contact-arm carried by the gyroscope, an adjustable plate or disk carrying said segment, movable to varying angles around the axis on which the gyroscope turns, and a spindle engaging said disk for turning it and passing through said ring to be operated from the exterior, whereby the circuit-closer may be set to varying angles from the exterior of the hull.

26. In an automobile torpedo or analogous craft, the combination with the hull thereof, its steering-rudder, a gyroscope for controlling said rudder, an electric circuit constitut-

ing part of the connection through which the gyroscope controls the rudder, a circuit-closer controlling said circuit and operated by the gyroscope, and an adjustable plate carrying said circuit-closer and movable to varying angles around the axis upon which the gyroscope turns, whereby the preliminary adjustment of said plate to any angle determines the direction of the course in which the torpedo shall be steered.

27. In an automobile torpedo or analogous craft, the combination with the hull A thereof, its steering-rudder L, its operating-rod *u* within the hull, a spring acting against said rod, and an elbow-lever *u'* connected to said rod, of a gyroscopic apparatus comprising a base-ring B fitting into an opening in said hull, a gyroscope carried thereby, and a fluid-pressure steering-engine N also carried thereby and terminating in a plunger P which when the gyroscopic apparatus is in place acts against one arm of said elbow-lever in opposition to said spring.

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

FRANK M. LEAVITT.

Witnesses:
ARTHUR C. FRASER,
FRED WHITE.