S. Z. DE FERRANTI.

GYROSTAT.

APPLICATION FILED OCT. 14, 1910.

1,112,997.

Patented Oct. 6, 1914.

6 SHEETS—SHEET 1.

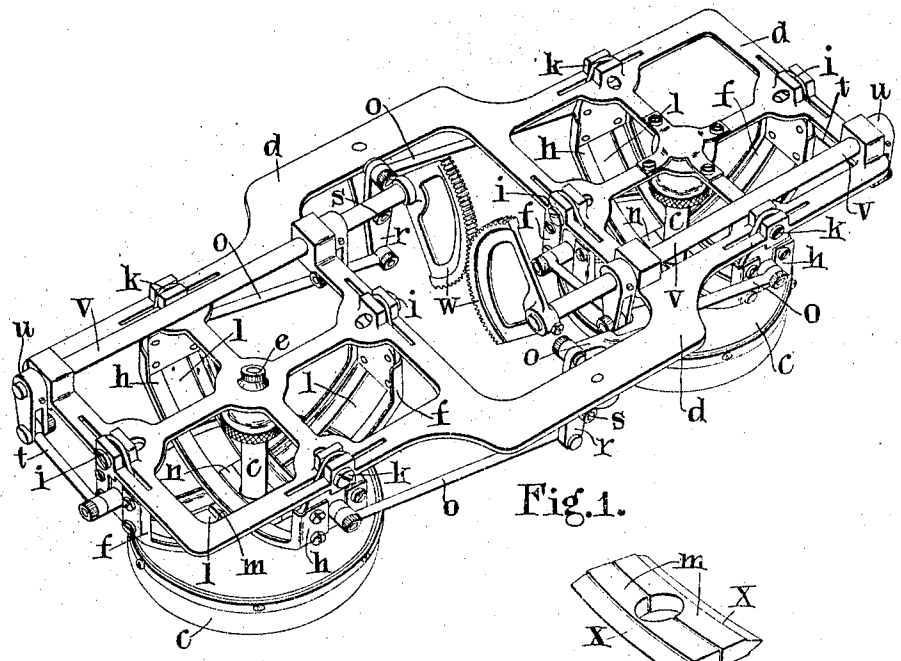


Fig. 1.

Fig. 3.

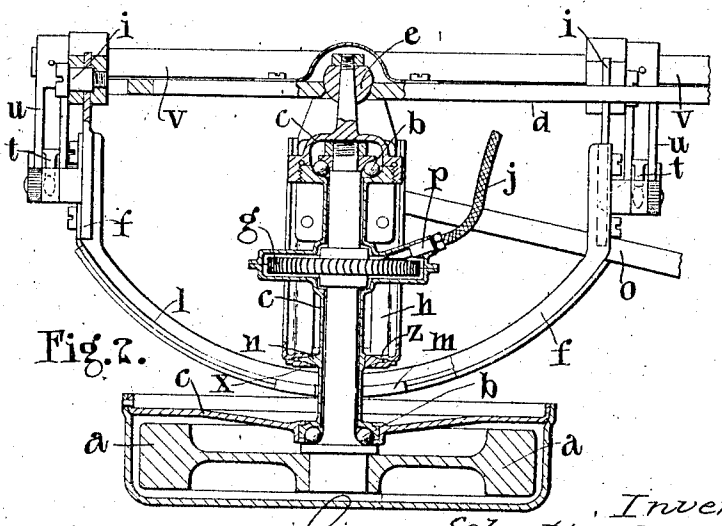


Fig. 2.

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L. B. Middleton

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by Crosby Middleton Donaldson & Gray

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6 SHEETS—SHEET 2.

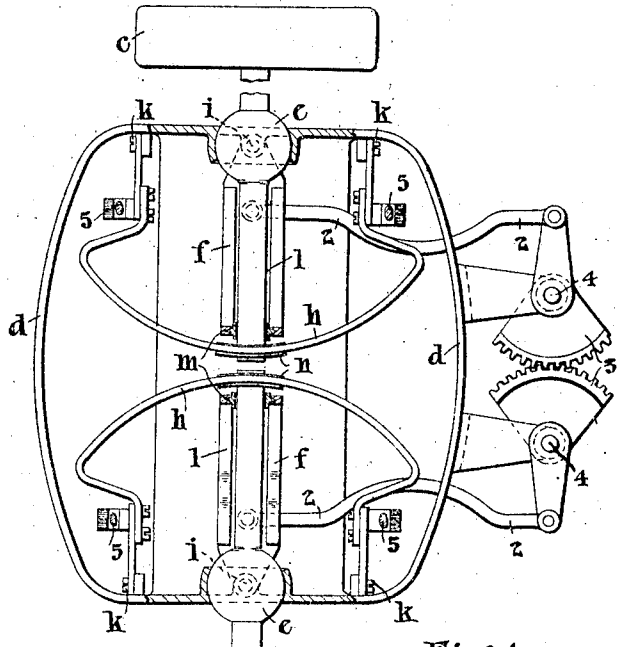


Fig. 4.

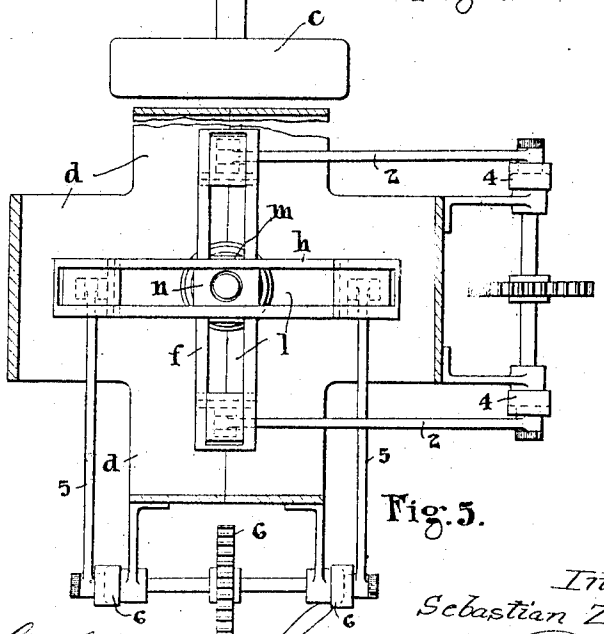


Fig. 5.

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6 SHEETS—SHEET 3.

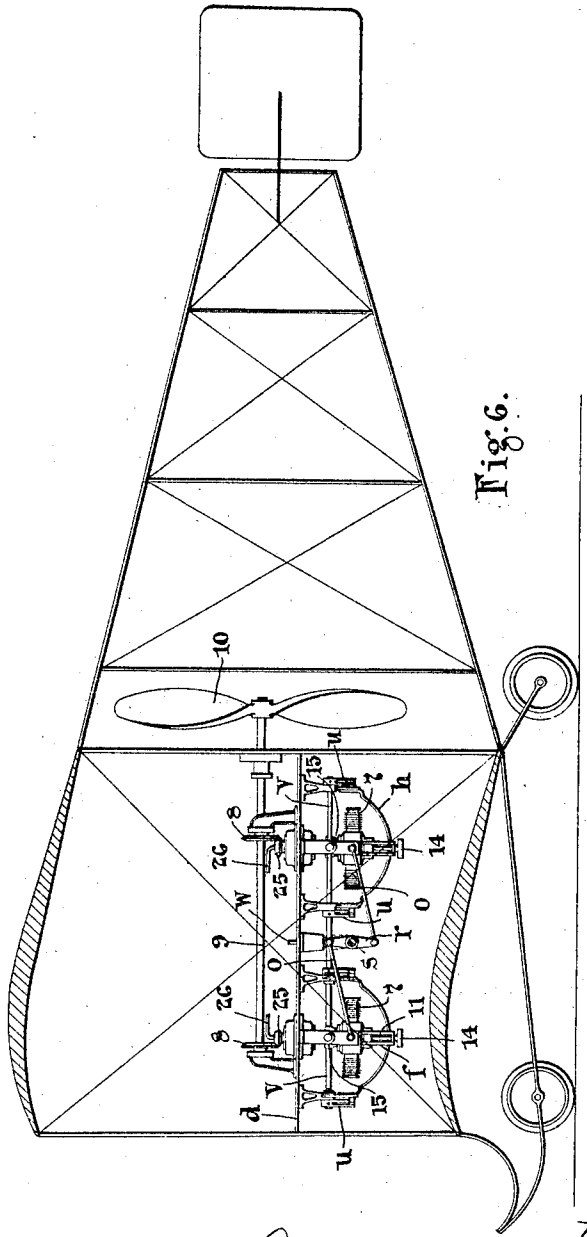


Fig. 6.

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6 SHEETS—SHEET 4.

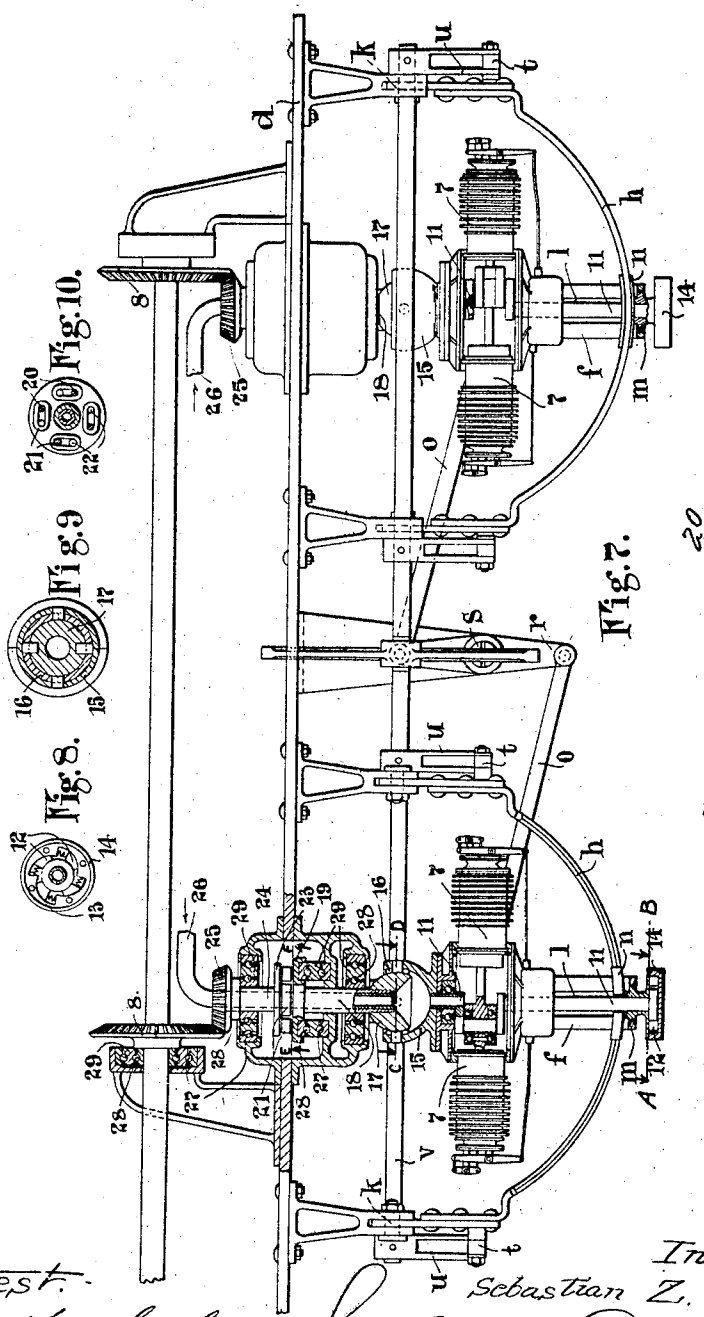


Fig. 10.

Fig. 9.

Fig. 8.

Fig. 7.

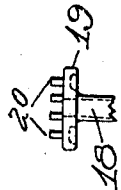


Fig. 10a.

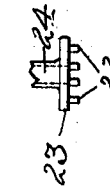


Fig. 10b.

Witnesses:

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APPLICATION FILED OCT. 14, 1910.

1,112,997.

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6 SHEETS—SHEET 5.

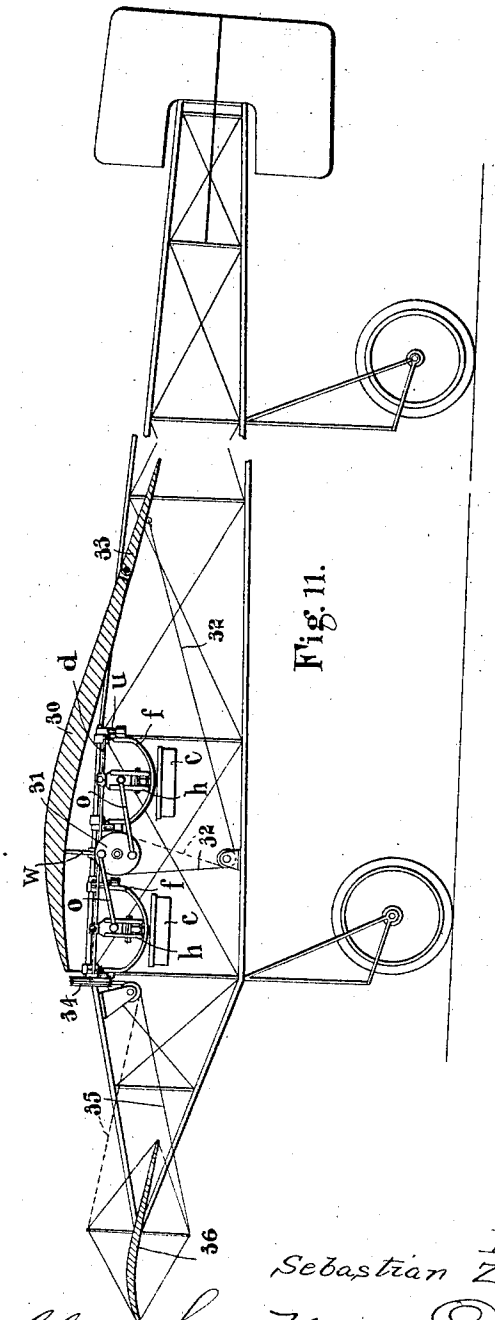


Fig. 11.

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Patented Oct. 6, 1914.

6 SHEETS—SHEET 6.

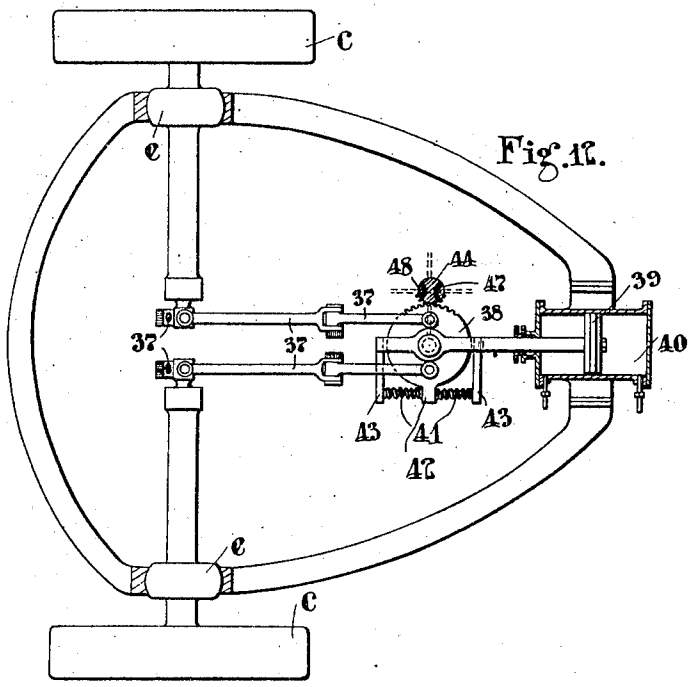


Fig. 12.

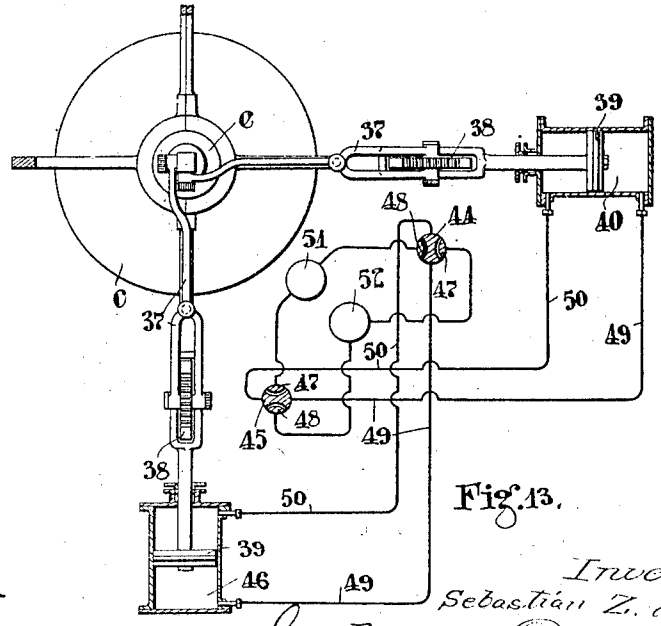


Fig. 13.

Witnesses:

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UNITED STATES PATENT OFFICE.

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GYROSTAT.

1,112,997. Specification of Letters Patent. Patented Oct. 6, 1914.

Application filed October 14, 1910. Serial No. 587,104.

To all whom it may concern:

Be it known that I, SEBASTIAN ZIANI DE FERRANTI, a subject of the King of Great Britain and Ireland, and residing at Grindleford, in the county of Derby, England, have invented certain new and useful Improvements in Gyrostats, of which the following is a specification.

The present invention relates to the gyroscopic steadying of bodies and is applicable either to a case in which additional stability is imparted to an initially stable body or to a case in which stability is to be imparted to an initially unstable body or to a case in which stability is neutral.

Two different methods of gyroscopic steadying have been proposed heretofore, the direct and the indirect. According to the former or direct method, the freedom of the gyroscopes to move in some particular direction with reference to the body on which they are mounted, and which it is their primary function to stabilize is necessarily restrained to a certain extent so that the stabilizing forces due to the gyroscopes may be directly transmitted by way of the members imposing such restraint to the body in question; an example of this method, which in order to obtain the best results in general involves either a retardation or an acceleration of the precessional movement of the gyroscopes, is to be found in the well-known Brennan monorail vehicle. According to the latter or indirect method on the contrary, movement of the gyroscopes relatively to the body which it is their ultimate function to stabilize is utilized to operate auxiliary balancing devices either by direct mechanical connections or in some cases through the instrumentality of a relay.

The present invention relates more particularly to the application of the direct method of steadying or stabilizing, though as will appear hereinafter, in some cases it is also applicable to the indirect method.

In order to avoid practical difficulties particularly in connection with the steering in systems of the type referred to, as applied to ships, monorail vehicles, and so forth, it has been proposed to employ two gyroscopes for steadying the body in a given plane, *e. g.*, a transverse vertical plane and if the body is also to be steadied in a longitudinal vertical plane to employ two more gyroscopes. In other cases, a single gyroscope has been proposed for imparting stability to the body in say the transverse direction and a second gyroscope for performing a similar function in the longitudinal direction. In all such cases, however, the particular gyroscope or pair of gyroscopes, which according to such proposed systems controls what for simplicity may be called the rolling motion of the body, is restrained in such a manner that it has no effect in controlling the pitching motion and vice versa so that the total mass embodied in the system is not used to the best advantage.

Now the primary object of the present invention is to provide a gyroscopic system in which a much more efficient utilization of the rotatable mass available is rendered possible. To this end the present invention consists broadly in a pair of gyroscopic units mounted on a body so that each unit acts to impart stability thereto in every direction.

In general it is necessary to provide means for either retarding or accelerating the rate at which the gyroscopes precess.

The present invention is applicable to the steadying not only of ships, submarines, aeroplanes hydroplanes, and many other vehicles but also of naval gun platforms, ships' saloons, cabins, couches or otherwise.

Where the body to which the invention is applied or to which any other gyroscopic steadying system is applied carries one or more motors for propulsion or other purposes, I may in some cases use suitable rotary parts of such motors as the necessary gyroscopic mass. In such cases and especially where my invention is applied to aeroplanes that type of motor in which the cylinders revolve around the crank-shaft is particularly suitable. It is of the utmost importance in such an application, no matter what the precise type of motor adopted that even if one of the motors fails, the gyroscopic control should be maintained in order to effect a safe landing.

Another part of the invention thus consists in providing means whereby if the motor fails, the standing parts of the same will be automatically released and the whole motor will rotate bodily in virtue either of its stored energy or a connection by which it is geared to another motor, the motor being preferably released also automatically from the propeller or the like driven thereby.

The invention finally consists in the novel forms of gyroscopic control, applications and

details of the same hereinafter described and particularly pointed out in the claims.

Referring now to the accompanying drawings which form part of the present specification: Figure 1 shows a perspective view of one form of the invention with the driving turbine omitted for the sake of clearness, Fig. 2 being a corresponding section through one of the gyroscopes, showing driving turbine and nozzle and, Fig. 3 a perspective view of a pair of friction blocks; Fig. 4 shows an elevation of a modification of the invention in which the gyroscopes are placed one above the other, Fig. 5 being a corresponding plan; Fig. 6 shows a general view of a biplane driven by motor gyroscopes, Fig. 7 being a detail on a larger scale of the gyroscopic engines and their adjuncts partly in section, while Figs. 8, 9 and 10 show respectively sections on the lines A—B, C—D, and D—E of Fig. 7, through the automatic clutch, universal joint and elastic drive; Figs. 10^a and 10^b show other details of the elastic drive. Fig. 11 shows a general view of a monoplane in which the movements of the gyroscopes are employed to operate ailerons and an elevator, while finally Fig. 12 shows an elevation partly in section of a form of the invention in which forced precession is employed, Fig. 13 being a corresponding plan showing the connections.

The drawings are to a considerable extent of a diagrammatic nature, various elements of the complete apparatus which are well known to those skilled in the art being shown only conventionally.

Where desirable the same reference symbols are used in the different figures to denote corresponding parts.

I will now describe one form of my invention suitable for attachment direct to an aeroplane for example. According to this form (see Figs. 1, 2 and 3) I provide a pair of gyroscopes, *a*, mounted on ball-bearings, *b*, within suitable casings, *c*, and I suspend these from a frame, *d*, their highest points being held in a ball-and-socket joint, *e*, or any equivalent mounting which will allow the gyroscopes to swing in any direction. Each gyroscope, as shown in Fig. 2, may be driven by a turbine, *g*, mounted on the gyroscopic spindle and supplied with working fluid by way of the flexible connection, *j*, and nozzle, *p*, carried by the casing *c*; the casing may conveniently be held from turning by fixing it to one half of the friction block, *n*, hereinafter referred to.

In the present form of the invention as in all others, the best results are obtained by using a pair of like gyroscopes and rotating them at the same speed in opposite directions.

In order to impose the necessary restraint on the gyroscopes, I mount each of them within a pair of U-shaped frames, *f*, *h*, the frames of each pair being arranged at right angles to each other as shown. Each of these frames, moreover, is pivoted at its upper end so as to be able to swing about a horizontal axis, the frames, *f*, turning about the pivots, *i*, and the frames, *h*, about the pivots, *k*. The lower member of each U-frame is concentric with the center of the ball-and-socket joint and is provided with a slot, *l*, as shown, in which slide blocks, *m*, *n*, which may conveniently be formed in halves with rubber interposed. Any other device may be employed to force the half blocks apart. Corresponding members of the U-frames are connected by suitable gearing so that they can swing only in opposite directions. Thus, as regards the frames, *h*, links, *o*, connect them to opposite ends of the double lever, *r*, pivoted at its middle point, *s*, to the main frame, *d*, this construction preferably being duplicated as shown. As regards the frames, *f*, each of these is connected by a pair of links, *t*, to levers, *u*, mounted on a spindle, *v*, the two spindles being mounted on opposite sides of the main frame, *d*, and connected at their inner ends by segmental spur wheels, *w*, as shown.

Assuming the main frame, *d*, in the horizontal position, it will thus be seen that the pair of interconnected frames, *f*, prevents the gyroscopes from swinging in the same directions in planes normal to the axes of the pivots, *i i'*, of the frames, but by virtue of the slots, *l*, freely allows opposite precessions in line with the pivots, *i i'*, while the other pair of interconnecting frames, *h*, prevents both gyroscopes from swinging in the same direction in the plane in which opposite precessions were allowed by the first pair of frames, while similarly allowing opposite precessions in directions at right angles to said plane. Consequently, taking the interconnections between the gyroscopes as a whole, it will be seen that the latter rigidly resist or are so to say locked to, the frame as regards any disturbing force, no matter what its direction, which tends to tilt them similarly in relation to the frame on which they are mounted and yet are able to move in opposite directions to each other at right angles to the disturbing force. The interconnections therefore act not only to define the swing of the gyroscopes in relation to one another, but by virtue of their pivotal relation to the body to be stabilized act also to transmit to the body precessional forces set up by the gyroscopes, this transmission of forces taking place notwithstanding the fact that each of said gyroscopes is universally mounted on said body. The gyroscopes have therefore just that degree of restraint required to enable them to be used to oppose tilting couples acting on the aeroplane, no matter in what vertical plane said couples act. the inter-actions of the cross frames and

the gyroscopes in the example described being symmetrical as regards planes at 45° to the longitudinal and transverse directions while in other planes, the pairs of interconnected frames move to different and varying degrees.

In the case of a body such as the aeroplane in question which possesses normally a certain degree of stability, it is necessary or desirable to retard the precession of the gyroscopes and where I speak in this specification of "free precession", I means precession subject to such retardation. In order to obtain the best results, such retardation should increase with the disturbing force. This object I may achieve very simply in gyroscopic systems as herein described or otherwise by providing suitable rubbing surfaces such as those of the blocks, *m*, *n*, above mentioned and the walls of the slots in which they move, the friction and retardation thus varying in accordance with the pressure between them and therefore with the disturbing force.

In particular, as shown in Fig. 3, I may form the co-acting rubbing surfaces of the blocks and slot-wall, the one with a V-shaped projection, *x*, and the other with a V-shaped groove, *z*, coöperating with the projection. I may vary the amount of the retardation in proportion to the disturbance by varying the angle of the V or by equivalent means.

According to a modification (see Figs. 4 and 5) I may arrange the gyroscopes within casings, *c*, as before described with their vertical axes in line, instead of side by side, the one gyroscope having a ball-and-socket, *e*, or equivalent mounting at its upper end and the other at its lower end. The free ends of the gyroscope casings pass through slots in the U-frames, *f*, *h*, pivoted respectively at *i*, and *k*, these frames being interconnected by suitable linkages as before. Thus, the frames, *f*, are connected by rods, 2, to corresponding ends of the quadrant levers, 3, pivoted at 4, these quadrants gearing into one another as shown. Similarly the frames, *h*, are geared together by rods, 5, and quadrants, 6. By thus interconnecting the gyroscopes by members corresponding in function to those already described, I provide precisely the same peculiar restraint and so secure the same control. In the present case, it will be seen that the pair of interconnected frames, *f*, prevents the gyroscope swinging in directions or planes normal to the axis of the pivots, *i*, of these frames in the same rotational direction (*e. g.*, both in a clockwise or both in a counterclockwise direction in the north-south planes) but freely allows opposite precessions in a direction or plane at right angles (*e. g.*, the east-west vertical plane through the pivots *i*, *i*,) while the other pair of interconnected frames *h*, prevents swinging of the gyroscopes in the same rotational direction in the direction or plane in which opposite precessions were allowed by the first pair of frames (*e. g.*, the east-west vertical plane through the pivots *i*, *i*,) while similarly allowing opposite precessions in those directions or planes (*e. g.*, north-south planes normal to the axis of the pivots, *i*, *i*) in which swinging in the same rotational direction was prevented.

The north-south, east-west, or other planes of swing may for the purposes of this specification be termed "directional planes."

It will be seen from this description that the mass of the gyroscopes according to the present invention is utilized much more efficiently than heretofore, since each gyroscope exercises effective control no matter in what direction the aeroplane tends to tilt.

I prefer as above indicated that the rotating members of the motors should themselves act as the gyroscopes, and such an application of my invention I have shown in general view in Fig. 6 and in detail in Figs. 7, 8, 9 and 10. According to this application of my invention the motors, 7, which may conveniently be of the type in which the cylinders themselves rotate, a well known example of which type is to be found in the "Gnome" motor, are mounted so as to rotate about a vertical axis in such a manner that they are free to swing in any direction, the drive being transmitted through bevel wheels, 8, to a common shaft, 9, driving the propeller, 10. Turning to the detail view of this application of my invention, it will be seen that the stationary shaft, 11, of the motor is prevented from turning under normal circumstances by the one-way device or clutch shown in detail in Fig. 8. This clutch consists of spring-controlled wedges, 12, co-acting on the one hand with the shaft, 11, and on the other hand with the stepwise inclined walls, 13, of a casing, 14, attached to the blocks, *m*, sliding in one of the pivoted U-frames. The revolving parts of the motor are supported by a substantially air-tight universal joint. The motor casing itself is shaped with an appropriate spherical portion, 15, in which pivots and fits a ring, 16, with spherical surfaces both on its outer and inner surfaces, this ring in turn fitting and being pivoted to as much as is required of a sphere, 17, rigidly attached to a sleeve, 18, supported in ball bearings as shown. Near the upper end of the sleeve, 18, a disk or collar, 19, is formed provided with projecting pins, (see Fig. 10[a]) 20, which by means of leather or rubber rings, 21, co-act as shown in Fig. 10 with corresponding pins, 22, projecting downwardly from a disk or collar, 23, (see Fig. 10[b]) forming part of a hollow shaft, 24, which at its upper end carries a bevel wheel, 25, and passes downwardly through the sleeve, 18, as shown.

The object of the flexible drive described is to equalize as much as possible the variations in the velocity ratio transmitted through the universal joint when the motors swing from their central position. With such an arrangement carbureted air can enter by the inlet, 26, and pass down the hollow shaft, 24, to the motor.

As indicated I prefer to use a special form of duplex bearing wherever needed as a precaution against failure, such a bearing consisting in essence of two concentric series of balls, 27 and 28, separated by a live ring, 29. The ball races and ring should be so closely assembled, and it may be, checked into each other that in case of ball failure the relative position of the parts, will be maintained. With such a bearing the breakage of any individual ball in such a way as to cause failure of the series to which it belongs would not prevent the parts concerned continuing to rotate on the undamaged series of balls. Instead of ball bearings, I may in some cases use two ordinary bush bearings, the one within the other or a combination of a bush and ball bearing.

The U-frames and interconnections in this modification of the invention are similar to those described above and will not be referred to again here. Supposing in such an arrangement that one of the motors should fail, the re-acting torque on the stationary shaft, 11, would cease to act and so free the clutch, thus enabling the cylinders and shaft of the motor to revolve bodily either in virtue of their stored energy or the power supplied from the undamaged motor. Again I may arrange a clutch between a motor and a propeller so as to be able to stop the latter without losing the gyroscopic effect, the object throughout in this part of the invention being to provide as far as possible for maintaining the gyroscopic control under all conditions, including even failure of individual parts of the apparatus.

An aeroplane such as described above may be steered on an even keel by the usual rudders, since the plane of rotation of the gyroscopes is horizontal while the aeroplane may be caused to ascend or descend by adjustment of the whole plane system (including tail and elevators if any) in relation to the gyroscopic system. Or again, the required alterations in direction may be effected by utilizing the precessional couples due to forces applied to the controlling gyroscopes in any suitable manner, or one or more special gyroscopes may be used for the purpose. Moreover, if I desire to ascend or descend I may lock the gyroscopic system so that it loses its controlling effect in the longitudinal vartical plane and thus freely allows steering up or down by means of a horizontal rudder. Furthermore, I may provide an aeroplane with a gyroscopic system according to my invention, which in addition to imparting stability directly also acts indirectly to obtain the same effect by operating suitable elevators, ailerons, wing-flexing devices or otherwise. One example of such a modification (as applied to an aeroplane having a main supporting member, 30), is shown diagrammatically in Fig. 11 in which the downwardly hanging gyroscopes, U-frames and interconnections are substantially as described with reference to Fig. 1. In this example the double lever, *r*, of Fig. 1 is replaced by a pulley 31, over which wires, 32, or the like pass to operate the ailerons, 33. Moreover, on the U-frame, *f*, a second pulley, 34, is rigidly attached coaxially therewith, other wires, 35, passing over this pulley to operate the elevator, 36.

It will be seen that if the aeroplane tilts laterally the gyroscopes will be caused to precess in a fore-and-aft direction, thereby turning the pulley, 31, and operating the ailerons in such a way as to restore the aeroplane to the horizontal position, while if on the contrary the machine should tend to pitch, the second pulley, 34, would turn owing to the precession of the gyroscopes in lateral directions, and thereby operate the elevator to restore equilibrium.

I may likewise apply my invention and the above described forms thereof to the case of bodies possessing no initial stability, in which case some known or suitable means must be provided for accelerating the precession. Thus referring to Figs. 12 and 13 which illustrate one form of this part of my invention in which the gyroscopes are placed one above the other, as in a previous example described, the gyroscopes are as before supported in ball and socket joints to swing in any direction. Their adjacent free ends are connected by links, 37, to a toothed disk, 38, carried by the cross-head of a piston, 39, working in a cylinder, 40, the links being arranged as shown one above and one below the center of the disk. Suitable springs, 41, are arranged co-acting between lugs, 42 and 43, on the disk and cross-head respectively to return the parts after disturbance to their central position. The toothed disk itself gears with corresponding teeth attached to a rotary valve, 44. A precisely similar arrangement to that described is provided in a direction at right angles as seen in Fig. 13, the parts including a second valve, 45, and a second cylinder, 46. A peculiarity of this form of the invention consists in cross-coupling the valves respectively each to the cylinder of the other set of mechanism. The valves, as shown in the diagrammatic view are provided with passages, 47 and 48, which enable the pipes, 49 and 50, to the cylinders to be connected as required to a source of fluid pressure, 51, and an exhaust, 52.

The action of the device described is as follows: Supposing in Fig. 12 that the axes of the gyroscopes are vertical and lie in the same fore-and-aft plane of the body to which they are applied as the axis of the cylinder, then if the body were to pitch the free ends of the gyroscopes as explained above in a previous example would move slightly in opposite directions, thereby rotating the toothed disk, 38, and thus the rotary valve, 44, thereby admitting pressure fluid to the cylinder, 46, and forcing the gyroscopes to precess in a plane at right angles to that of the plane of the figure. The suspension of the gyroscopes with their axes normally vertical provides so to say a datum or base line from which the apparatus may work. In this case, as before, I am enabled to impart stability to the body to which my invention is applied in all vertical planes by the use of only two gyroscopes.

In this, as in all other modifications of my invention, however, each gyroscope acts to impart stability in all directions.

I wish it to be understood that although in order to make clear the nature of my invention I have described certain specific examples thereof in considerable detail, nevertheless it will be evident that the novel principles involved can be embodied in a great variety of different forms.

Having now described my invention what I claim as new and desire to secure by Letters Patent is:—

1. In combination, a body, and means for automatically opposing tilting couples acting thereon irrespective of the direction of the axes of said couples, said means including a pair of gyroscopic units each universally mounted thereon to swing relatively to said body through substantial angles in any direction, and means for restraining said units from simultaneously so swinging in the same rotational direction relatively to said body.

2. In combination, a body, and means for automatically opposing tilting couples acting thereon irrespective of the direction of the axes of said couples, said means including a pair of gyroscopic units each universally mounted thereon to swing relatively to said body through substantial angles in any direction, and means for constraining said units so to swing in opposite rotational directions relatively to said body.

3. In combination, a body, and gyroscopic means for directly applying thereto precessional couples to oppose tilting couples acting on said body irrespective of the direction of the axes of said couples, said means including a pair of gyroscopic units each universally mounted thereon in stabilized equilibrium, and means for constraining said units to swing in opposite rotational directions relatively to said body.

4. In combination, a body, and gyroscopic means for directly applying thereto precessional couples to oppose tilting couples acting on said body irrespective of the direction of the axes of said tilting couples, said means including a pair of pendulous gyroscopic units, each universally mounted thereon, and means for constraining said units to swing in opposite rotational directions relatively to said body.

5. In combination, a body having a pair of gyroscopic units universally mounted thereon; and means for preventing said units swinging simultaneously in the same rotational direction in any the same directional plane while permitting swinging in opposite rotational directions in said same directional plane.

6. In combination, a body having a pair of gyroscopic units universally mounted thereon; mechanical interconnections for preventing inclining of the individual units relatively to said body in the same rotational direction in a certain directional plane while allowing precession in opposite rotational directions in a directional plane at right angles and other mechanical interconnections for preventing inclining in the same rotational direction in the directional plane at right angles while allowing precession in opposite rotational directions in the first-mentioned directional plane.

7. In combination, a body and gyroscopic means for directly applying thereto precessional couples to oppose tilting couples acting thereon irrespective of the direction of the axes of said couples, said means including a motor having gyroscopic rotary parts universally mounted on said body to swing through substantial angles in any direction; a second gyroscopic mass similarly mounted on said body and means for constraining said units to swing in opposite rotational directions relatively to said body.

8. In combination, a body and gyroscopic means for applying thereto stabilizing precessional couples, said means including rotary parts of a motor having cylinder and crank shaft members both rotatably mounted on said body; together with one-way means for holding one of said motor members stationary during normal working of said motor and releasing said member during certain other working conditions.

9. In combination, a body; a pair of gyroscopic units each having a separate universal mounting thereon to allow said units to swing relatively to said body through substantial angles in any direction; swing-defining interconnections operatively associated with said gyroscopic units and having members in force-transmitting relation to

said body, together with means for transmitting precessional forces from said gyroscopic units to said body directly to stabilize the same, said means including the force-transmitting members of said swing-defining connections.

10. In combination, a body; a pair of gyroscopic units each having a separate universal mounting thereon to allow said units to swing relatively to said body through substantial angles in any direction; swing-defining interconnections operatively associated with said gyroscopic units, together with means for transmitting stabilizing precessional couples from each of said gyroscopic units to said body, said means including in respect of each of said units said swing-defining connections.

11. In combination, a body and gyroscopic means for applying thereto stabilizing precessional couples, said means including a motor having a rotor member and a universal power-transmitting mounting supporting said motor; propelling means for said body; means for operatively connecting said rotor member with said propelling means, said connecting means including said power-transmitting mounting, together with means for supplying working fluid to said motor by way of said power-transmitting mounting.

12. In combination, a body and gyroscopic means for applying thereto stabilizing precessional couples, said means including a motor having a rotor member and a universal power-transmitting mounting supporting said motor; propelling means for said body; means for operatively connecting said rotor member with said propelling means, said connecting means including said power-transmitting mounting and including also a flexible coupling, together with means for supplying working fluid to said motor by way of said power-transmitting mounting.

13. In combination, a body and gyroscopic means for applying thereto stabilizing precessional couples, said means including a motor having cylinder members rotatably mounted on said body; a crank shaft member also rotatably mounted on said body and one-way means for holding said crank shaft member stationary during normal working of said motor, and releasing said crankshaft member during certain other working conditions.

14. In combination, a body having a pair of gyroscopic units universally mounted thereon and means for constraining said units to swing in opposite rotational directions, said means including a plurality of U-frames to each unit, said U-frames being each pivotally mounted on said body and interconnections between corresponding frames coöperating with different units.

15. In combination, a body; gyroscopic means mounted thereon to allow precession of the axis of said gyroscopic means in a certain plane; together with means for retarding said precession, said precession-retarding means including a member receiving in a direction at right angles to said certain plane, thrust due to said precession and including also a member transmitting thrust from said gyroscopic means to said thrust-receiving means, one of said members having associated therewith a groove and the other of said members a projection co-acting with said groove.

16. In combination, a body; gyroscopic means mounted thereon to allow precession of the axis of said gyroscopic means in a certain plane; together with means for retarding said precession, said precession-retarding means including a member receiving in a direction at right angles to said certain plane, thrust due to said precession and including also a member transmitting thrust from said gyroscopic means to said thrust-receiving means, one of said members having associated therewith a V-shaped groove and the other of said members a V-shaped projection co-acting with said groove.

17. In combination, a body; a pair of gyroscopic units each having a separate universal mounting thereon to allow said units to swing relatively to said body through substantial angles in any direction; swing-defining interconnections operatively associated with said gyroscopic units and having members pivotally mounted on said body, together with means for transmitting stabilizing precessional couples from said gyroscopic units to said body, said means including said pivotally-mounted members.

18. In combination, a body having a pair of gyroscopic units universally mounted thereon to swing through substantial angles in all directions; positive connecting means between said units for constraining them to swing in opposite rotational directions relatively to said body; together with means for controlling the movement of said body and means for transmitting swinging movement of said gyroscopic units to said controlling means.

19. In combination, a body having a pair of gyroscopic units movably mounted thereon; inter-connections for constraining said units to swing in opposite rotational directions relatively to said body; together with means for controlling the movement of said body and means for transmitting movement of said units to said controlling means, said transmitting means including said swing-constraining interconnections.

20. In combination a body; propelling means therefor; motor means having rotary parts and driving said propelling means; a

pair of gyroscopic units, at least one of which is constituted by rotary parts of said motor means, each of said gyroscopic units having a separate universal mounting on said body; swing-defining interconnections operatively associated with said gyroscopic units and having members in force-transmitting relation to said body, together with means for transmitting stabilizing precessional forces from said gyroscopic units to said body, said means including the force-transmitting members of said swing-defining connections.

21. In combination a body; a pair of gyroscopic units universally mounted thereon; means for defining swinging movement of said gyroscopic units in relation to each other, said means including a plurality of U-frames for each unit, each of said U-frames being pivotally mounted on said body and means for restraining corresponding U-frames coöperating with different units from simultaneously swinging in the same rotational direction relatively to said body.

22. In combination a body; a pair of gyroscopic units universally mounted thereon; means for defining swinging movement of said gyroscopic units in relation to each other, said means including a plurality of U-frames for each unit, each of said U-frames being pivotally mounted on said body, and means for constraining corresponding U-frames coöperating with different units to swing in opposite rotational directions relatively to said body.

23. In combination a body; a pair of gyroscopic units universally mounted thereon; means for defining swinging movement of said gyroscopic units in relation to each other, said means including a plurality of U-frames for each unit, each of said U-frames being pivotally mounted on said body, and means for preventing corresponding U-frames coöperating with different units swinging simultaneously in the same rotational direction in any the same directional plane while permitting swinging in opposite rotational directions in the same directional plane.

24. In combination, a body; a pair of gyroscopic units universally mounted thereon in stabilized equilibrium; and means for constraining said units to swing in opposite rotational directions relatively to said body.

25. In combination a body; a pair of gyroscopic units universally mounted thereon and pendant therefrom; and means for constraining said units to swing in opposite rotational directions relatively to said body.

26. In combination, a body; gyroscopic means mounted thereon to allow precession of the axis of said gyroscopic means in a certain plane; together with means for retarding said precession, said precession-retarding means including a member receiving in a direction at right angles to said certain plane, thrust due to said precession.

In testimony whereof, I affix my signature in presence of two witnesses.

SEBASTIAN ZIANI DE FERRANTI.

Witnesses:
ALBERT HALL,
WILLIAM DUNCAN DAVIDSON.