Jan. 6, 1948. W. G. WILSON 2,434,187

STABILIZING AND STEERING OF AERIAL TORPEDOES OR BOMBS

Filed June 25, 1942 2 Sheets-Sheet 1

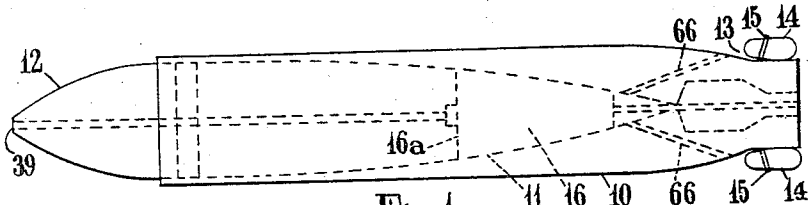


Fig. 1

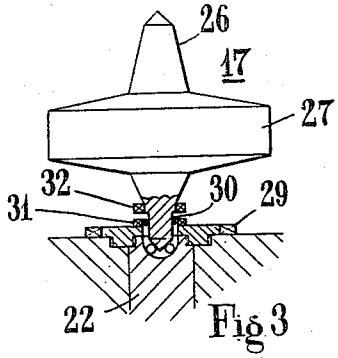


Fig. 3

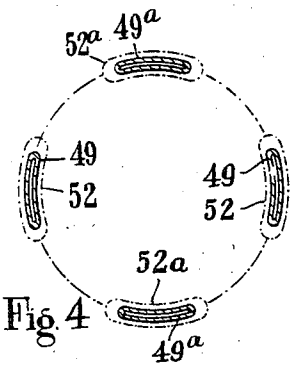


Fig. 4

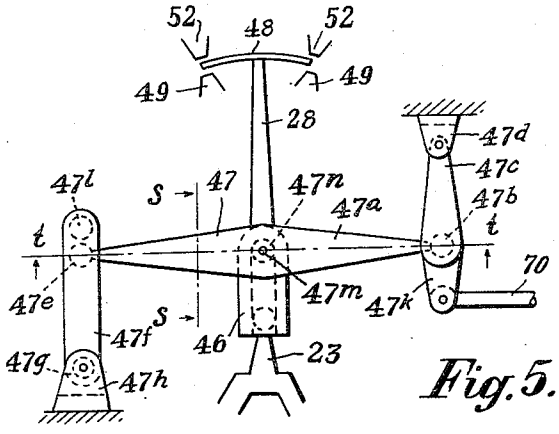


Fig. 5.

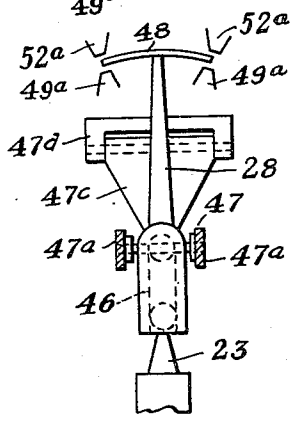


Fig. 6.

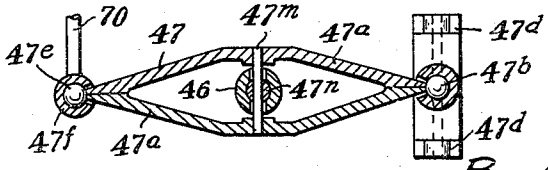


Fig. 7.

Inventor
W. G. Wilson
By Glascock Downing & Seebold
Attys

Jan. 6, 1948. W. G. WILSON 2,434,187

STABILIZING AND STEERING OF AERIAL TORPEDOES OR BOMBS

Filed June 25, 1942 2 Sheets-Sheet 2

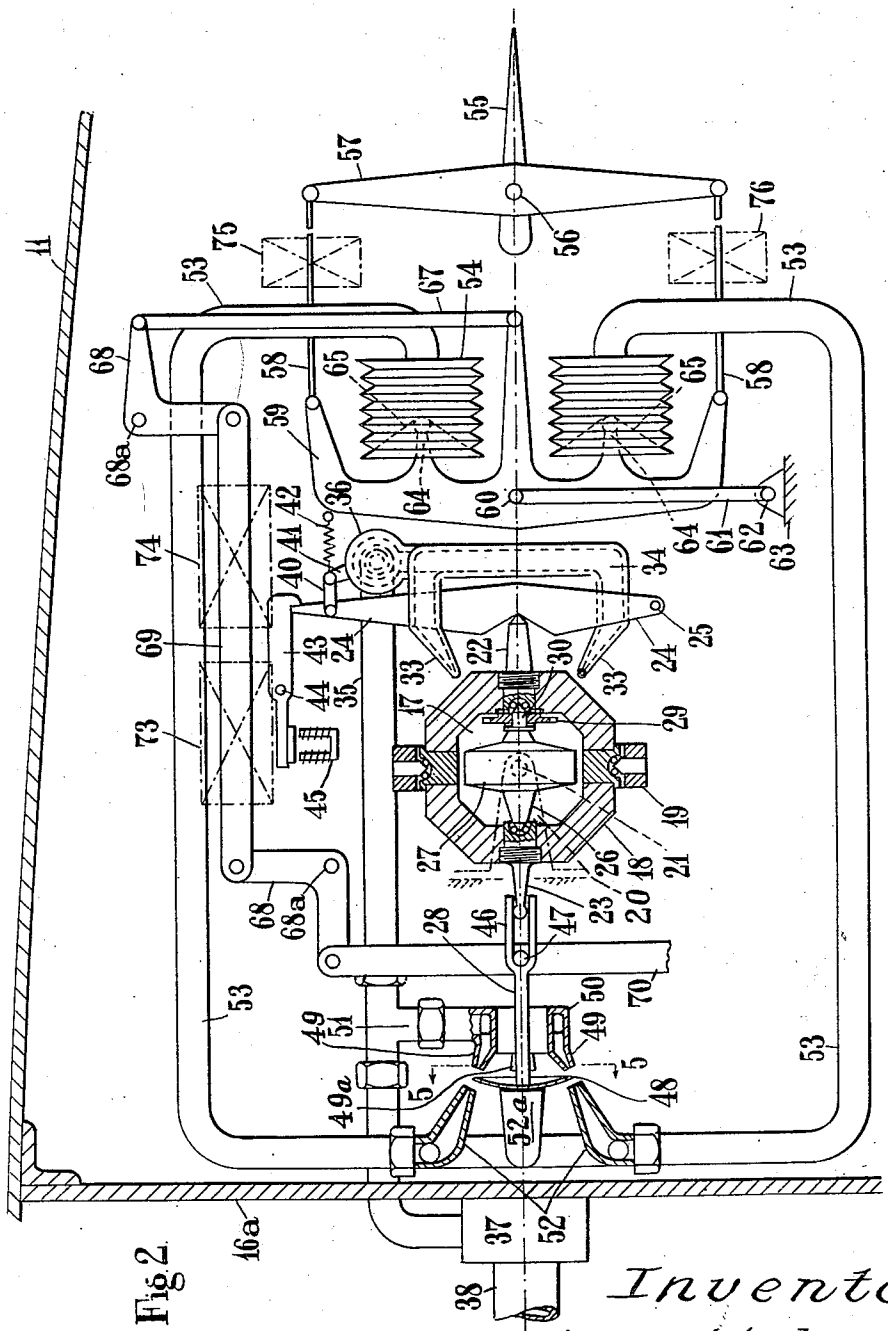


Fig. 2.

Inventor
W. G. Wilson
By Mascock Downing & Seebold
Attys

Patented Jan. 6, 1948 2,434,187

UNITED STATES PATENT OFFICE

2,434,187

STABILIZING AND STEERING OF AERIAL TORPEDOES OR BOMBS

Walter Gordon Wilson, Martyr Worthy, Winchester, England

Application June 25, 1942, Serial No. 448,506
In Great Britain February 11, 1941

6 Claims. (Cl. 244—78)

1

This invention relates to aerial torpedoes which are self-propelled, or to bombs which do not necessarily carry propelling means.

The object of the invention to be hereinafter described is to stabilise and control the steering of such weapons so that they will accurately follow a predetermined course at any desired range.

More particularly the invention will be described as applied for example to an aerial torpedo such as that which forms the subject of my United States application Ser. No. 448,505, dated June 25, 1942 now Patent No. 2,419,866 issued April 29, 1947.

The invention consists in an aerial torpedo or bomb fitted with a gyroscope, by the influence of which should the torpedo or bomb deviate from its predetermined course, a valve device is automatically actuated to supply pneumatic pressure to stabilising and controlling devices by which the torpedo or bomb is controlled, stabilised or guided back to its course.

The invention will now be described with reference to the accompanying drawings in which:

Figure 1 is a plan view of an aerial torpedo constructed in accordance with the invention.

Figure 2 shows in plan view on an enlarged scale the assembled stabilising and controlling devices, and particularly an interceptor valve in its relation to the gyroscope.

Figure 3 is a detail of the gyroscope.

Figure 4 shows a transverse section taken on the line 5—5 of Figure 2.

Figure 5 is an elevation of a detail hereinafter referred to;

Figure 6 is an elevation at a right angle to Figure 5 and partly in section on the line *s*—*s*.

Figure 7 is a reverse plan view in section taken on the line *t*—*t*, Figure 5.

In carrying the invention into effect as applied to an aerial torpedo shown in Figure 1, such torpedo comprises an outer cylindrical casing 10, and an inner concentric torpedo-shaped body 11, which is, except for the head 12, wholly contained within the outer casing 10. The slightly reduced tail end 13 is fitted with the usual steering and control devices of which only is shown a pair of elevators 14 pivoted on transverse bearings 15.

The steering, stabilising and controlling mechanism seen in Figure 2 is mounted in a compartment 16 of the inner torpedo body 11, formed by a bulkhead 16*a*. The principal stabilising device consists of a gyroscope denoted generally by 17, mounted in gimbals comprising an inner frame

2

18, which is in turn supported within an outer frame 19. Both of these members, as well as the gyroscope, are carried on ball bearings, and the outer frame 19 is carried by the fixture brackets 20 in bearings at right angles to those connecting the inner frame 18 with the outer frame 19. Only one of the brackets is shown in dotted lines. The axis of the bearing supporting the outer frame 19 from the fixed support 20 is shown at 21. The rotor of the gyroscope 17 is started up with its axis coaxial with that of the torpedo, but when the inner gimbal ring is unlocked by the lever 24, the torpedo is free to move in any direction relatively to the rotor axis owing to the bearings in the outer ring 19 being at right angles. For this purpose the gimbal frame 18 is fitted with bearing pins 22 and 23 in line with the longitudinal axis of the torpedo. The bearing pin 22 is coned at one end to rest in a footstep bearing lever 24 pivoted at 25 to a fixed part, the other end of the pin forming part of a ball bearing as shown to receive one end of the rotary spindle 26 of the gyroscope rotor body 27. The bearing pin 23 at the opposite side of the gimbal frame 18 has a similar ball bearing to support the other end of the gyroscope spindle 26, and the free ball-shaped end of this pin engages a lever 28 of the form and in the manner hereinafter described.

In order to set the gyroscope rotating its spindle 26 on one side is fitted with a vane wheel 29 freely slidable on part 30 of the spindle of the gyroscope and such wheel carries dogs or teeth 31 which co-operate with correspondingly formed dogs or teeth 32 on the spindle of the gyroscope as shown clearly in Figure 3. The vane wheel 29 and the seating are formed of magnetic material which will normally keep the vane wheel engaged on its seating, but when it is set in rotation by jets of air from the converging and tangentially arranged nozzles 33 impinging upon the vanes, the wheel moves forward so as to engage the dogs or teeth 31 on the vane wheel with the dogs or teeth 32 on the gyroscope spindle thereby causing it to rotate in its bearings.

The gyroscope and its frames must be truly balanced about the bearings supporting the frames when the vane wheel 29 is held on its seating by magnetic force.

To supply the current of air necessary to set the gyroscope spinning in readiness for the torpedo flight the jets 33 of which there may be any suitable number are carried by a hollow casing 34 which is fed with compressed air from a supply duct 35 through a plug or other valve 36,

the duct 35 being fed from a box 37 which is carried by the bulkhead 16a. The box 37 is supplied with air by a centre duct 38 which extends forward through the torpedo body and has an open inlet 39 in the centre of the head 12. A nozzle (not shown) blows air into the inlet 39 so that compressed air of relatively low pressure may be injected so that the gyroscope is set spinning and will gradually attain the high speed necessary in readiness for the flight, the valve 36 remaining open.

When the flight is about to commence, means are provided whereby the valve 36 is closed to shut off the supply of air and the primary air supply nozzle is disengaged. Synchronously with the closing of the valve, means are provided to leave the gyroscope free as much as possible from any frictional bias that might produce or tend to produce precessional movement. For this purpose the valve 36 is operated by means of a crank arm 41 linked at 40 to the bearing lever 24. The end of this lever is held in engagement by means of a spring 42, with one end of a trip lever 43 pivoted at 44 to a fixed pin, and the other end is adjacent a magnet 45 arranged in a suitable electric circuit which when energised by a press button or other actuating device (not shown) will withdraw the opposite end of the trip lever from the end of the bearing lever 24 so that by means of the spring 42 the latter is withdrawn from the bearing pin 22 of the gimbal frame 18, and the valve 36 is closed. The air jets being no longer in action the vane wheel 29 is withdrawn by magnetic attraction back upon its seating so that now the gyroscope disc 27 having already attained its high speed is left free to continue its rotation by its own inertia, and the force that might cause it to precess is removed. Thus at the moment the aerial torpedo is about to be started, the button or the device is operated so as to free the gyroscope and turn off the air jets which if allowed to continue to operate might be sufficient to cause precessional movement. Any means other than an electromagnet may, however, be used to release the trip lever.

Should the torpedo tend to deviate from its proper predetermined course means will now be described consisting of a special valve by which the necessary control is automatically exercised, and the deviation or other fault corrected.

For this purpose the bearing pin 23 on the gimbal frame 18 is made with a ball shaped end to engage in the tubular and slotted end 46 of a two-armed lever 28 and which latter is mounted upon a floating fulcrum 47. The floating fulcrum is also made so as to constitute a universal joint, as hereinafter described, and the opposite end of the lever 28 is fitted with a shield or table 48 of light weight forming part of a sphere having a curvature which is radial with the fulcrum 47. The unit consisting of the shield 48, the lever 28 and the tubular end 46 must be balanced about the fulcrum 47, and it is to be noted that the one arm of the lever 28 which comprises the tubular end 46 is shorter than the other arm of the lever which carries the shield 48. The shield is positioned between pairs of air supply nozzles 49 and 49^a, each pair being arranged at a right angle to the other, and similarly arranged pairs of air receiving nozzles 52 and 52^a, the nozzle of one pair being in relative alignment with the corresponding nozzle of the other pair. In the circular layout of these nozzles shown in Figure 4, the nozzles at the opposite ends of the horizontal diameter communicate with devices for controlling the rudder whilst the nozzles at the ends of the vertical diameter communicate with devices for controlling the elevators. In the following description, the devices for actuating the rudder are described, and it is to be understood that those for operating the elevators will be similar.

The universal mounting generally denoted by 47, consists of an open beam 47^a, having two arms joined together at opposite ends. One end is ball jointed at 47^b to a swinging link 47^c, pivotally supported by a fixed part 47^d, and the other being ball jointed at 47^e to a link 47^f, such link being supported by a ball joint 47^g carried by a fixed part 47^h. The lower end of the link 47^e is connected at 47^k to a rod 70 which as shown in Figure 2 forms the termination of a linkage system, hereinafter described, which is operatively connected with the vertical rudder. The link 47^f at its upper end is ball jointed at 47^l to a similar rod 70 from a second linkage system, operating in connection with a horizontal rudder, for example as used on aircraft. At the centre and between the arms of the open beam is carried a cross pin 47^m, in the centre of which is a ball 47^n, upon which ball is carried the slotted end of the shank 28 of the interceptor valve, the open end of the slot engaging with the ball-headed end of the pin 23 on the gyroscope.

The ball joints 47^b, 47^e and pin 47^m are all situated on the major axis of the beam 47^a, and when relative movement takes place between the gyroscope pin 23 and the slotted end of the valve stem 28 in the plane of the beam, the movement swings the links 47^c and 47^f and the spherical shield 48 is swung to the left or right as the case may be, to open communication either one of the pair of ports 49, 52, so that air can pass from one to the other and thus initially operate the vertical rudder. Should, however, the movement of the craft be such that relative movement between the gyroscope pin and the slotted end of the valve stem take place in a right angled direction to that shown in Figure 2, the spherical shield 48 will similarly control other pairs of nozzles 49^a and 52^a, as shown in Figure 6, to supply air to operate horizontal rudders to prevent the aircraft pitching. This cross swing of the valve shank is permitted by the rotation of the beam about its major axis on the ball joints 47^b and 47^e, and a slight swinging movement about the ball joint 47^g. Such a mounting of the valve shank permits movement in any direction except up or down.

All of the supply nozzles 49 are carried by a casing 50 which is fed with air by means of a branch pipe 51 from the air main 35 which forms an extension of the air pipe 38 into the open mouth 39 of which, see Figure 1, the air is forced during flight. Each nozzle 52 is at one end of a pipe 53, the other end of which opens into a bellows or a piston and cylinder device 54. With the intercepting valve formed by the shield 48, in mid-position between the two sets of nozzles 49 and 52, which control the rudder, the passage of air from one nozzle to the other is only partially prevented and the pressure generated by the two jets 49 in their co-axial receiving nozzles 52 will be equal, and a sufficient amount being allowed to pass for a purpose hereinafter referred to.

When however a deviation off the course occurs, the shield or the interceptor valve 48 will move to the left or right as the case may be, so that air is prevented from passing between the nozzles at one side and fully opening the nozzles

at the other side for the passage of air so that a selector action is thus produced. This movement of the interceptor valve is produced by a slight out of line positional change between the bearing pin 23, and the tubular end 46 of the lever 28 and caused by the axis of the gyroscope remaining stationary in space.

In the example shown in Figure 2, the pair of bellows 54 shown are intended to actuate a rudder 55 pivoted at 56 upon a two-armed lever 57, to the opposite ends of which are attached cables 58 which are in turn secured to the opposite ends of a lever 59 centrally supported at 60 by one end of a link 61, the other end of which is pivoted at 62 upon a suitable fixed bracket 63. The lever is fitted with short projecting pins 64 which ride upon recessed caps 65 on the movable end of the respective bellows 54. With the interceptor valve 48 in the mid-position shown in Figure 2, both bellows 54 as already stated, will be under equal pressure due to the small amount of pressure which is passing between both of those nozzles which control the rudder, and in this way both of the cables 58 are kept taut.

As shown in Figure 4 each nozzle 49 or 52 is somewhat narrow in width relatively to its length, and the nozzles 52 are somewhat larger than 49, as shown by the dotted lines.

Thus a very small displacement of the interceptor valve will close the receiving nozzle 52 on one side, and thus make a difference in pressure in the diametrically opposite receiving nozzle 52, thereby actuating the rudder. This amount of displacement is still further reduced by the difference in the proportionate length of the two arms of lever 28. It is moreover to be noted that by making the interceptor valve 48 concentric with the fulcrum 47, the action of the jets of air will not cause any displacing force that might otherwise cause the gyroscope to precess.

When by the movement of the interceptor shield 48, air is allowed to pass from one of the nozzles 49 to the corresponding nozzle 52 (for example either of the pair shown in section, Figure 2) air will pass down one of the pipes 53 and expand the corresponding bellows 54, for instance the upper one in Figure 2. The lever 59 is oscillated in an anticlockwise direction about its fulcrum 60 but as this fulcrum point is also movable about the link pivot 62, the cable 58 at the other end of the lever and normally actuated by the lower bellows is kept taut and the movement results in moving the rudder 55 in an anticlockwise direction to correct the steering for example. Should, on the contrary, the lower bellows be expanded, then the rudder will be turned in a clockwise direction. It will be understood that the rudder indicated in Figure 2 is mounted on the tail of the aerial torpedo in a manner well understood.

In a similar manner, the elevator 14, Figure 1, will be actuated by a similar pair of bellows 54 and another lever 59, by the other nozzles 49, 52. In either case the cables 58 would be led from the control compartment 16 through guide tubes 66, Figure 1, and from thence to convenient cranks or levers to actuate the elevators or rudders.

To prevent the correctional movements of the rudder or elevators or both, from swinging the torpedo too much in the opposite direction, i. e. prevent any "hunting" movement, the floating fulcrum point 47 of the interceptor lever is adapted when either of the bellows is operated to receive a compensating adjustment to bring the

interceptor valve 48 back to its normal position. This is provided for by connecting the centre part of each lever 59 to a link 67 connected through a pair of bell crank levers 68 each fulcrumed at 68a and a link 69 to one end of an arm 70 which carries the floating fulcrum 47 of the interceptor lever 28. Thus directly the rudder receives a correctional movement so the interceptor shield 48 is moved back and interposed between the nozzles which had been previously uncovered and thereby prevent the torpedo being swung over too far.

It must be understood that the fulcrum 47 is capable of movement in both directions at right angles to the arm 46. It is moved in the plane of the drawing, Figure 2, by the movement of the rudders to correct deviation in that plane and it is moved by a similar set of levers in a plane at right angles to the plane of Figure 2 by the movement of elevators to correct the deviation in that plane.

In Figure 2 it will be seen that the link 69 shows two rectangles 73 and 74 and that similar rectangles 75, 76 are shown in or on the cables 58. These are intended to indicate the interposition in these parts of devices which form the subject-matter of United States application Ser. No. 465,880 dated Nov. 17, 1942, now Patent No. 2,241,286 issued December 10, 1946, which are provided for the purpose of anticipating and allowing for a reciprocating yielding or rendering action in the transmission so as to adequately deal with the correctional adjustments which may become necessary.

The aerial torpedo or bomb will be so designed that the centre of mass and the centre of lift are brought together as closely as possible so as to stabilise the torpedo and prevent rolling movement about the major axis thereof.

By fitting the aerial torpedo with a gyroscope, accuracy of dive bombing at an increased height will be ensured as the axis of the torpedo will be maintained on the original line of release, and the gyroscope action may be supplemented by guiding wings on the torpedo casing. In this way the line of descent of the torpedo will follow almost a straight line and any possible error due to height will be very small, whilst any errors due to banking, side slip, acceleration etc. will be considerably reduced, if not altogether eliminated.

When the above-described steering and stabilising devices are applied to an aerial torpedo, it may be propelled in the manner described in the specification of my United States application Ser. No. 448,505 hereinbefore referred to with an initial start from the ground, or when the stabilising and steering devices are applied to a non-self-propelled bomb either of them may be catapulted or dropped from a moving aircraft thereby obtaining a flying start. Thus the torpedo or bomb will start with an initial velocity equal to the speed of the aircraft and will have only an acceleration equal to the vertical component of gravity less air resistance.

The same method of control is used when the torpedo or bomb is given its initial velocity by other means, and a time mechanism preferably worked by air stream can be introduced to alter the position of the fulcrum of the air interceptor valve so as to make a slight angle of descent on to the target at the correct range.

From the foregoing description it will be understood that a torpedo or bomb may be stabilised and steered with great accuracy for any range by the means described.

I claim:

1. An automatic controlling mechanism for the rudders of aerial torpedoes comprising in combination a constant direction non-precessional gyroscope rotor, a gimbal ring therefor, an arm projecting from the ring, a two-arm pivoted lever, one end of which engages the arm on the ring, a curved deflector shield on the other end of said lever having the curvature thereof centered, on the fulcrum of the lever, such fulcrum being so positioned in the length of the lever that the arm actuated from the gimbal ring is shorter than the arm which carries the deflector shield which is adapted to be oscillated about said fulcrum to one side or the other by relative movement between the lever and the arm on the gimbal of the gyroscope when the aircraft tends to deviate from its course, a pair of fluid pressure supply nozzles one on each side of the two-armed lever and adjacent one side of the deflector shield, a pair of corresponding pressure receiving nozzles adjacent the other side of the shield, each in line with its respective supply nozzle, a pivoted rudder device, a pair of servomotors for turning the rudder to one side or the other and a pipe connection extending from each receiver nozzle to one of the servomotors, so that when the deflector shield swings to one side, one of the supply nozzles is uncovered and allows pressure fluid to pass into the corresponding receiver nozzle to thereby actuate one of the servomotors to actuate the rudder to correct the deviation of the aircraft.

2. An automatic controlling mechanism for the rudders of aerial torpedoes comprising in combination a constant direction non-precessional gyroscope rotor, a gimbal ring therefor, an arm projecting from the ring, a two-arm pivoted lever, one end of which engages the arm on the ring, a deflector shield on the other end of said lever forming part of a sphere, the arc of which is centered on the fulcrum of the lever, such fulcrum being so positioned in the length of the lever that the arm actuated from the gimbal ring is shorter than the arm which carries the deflector shield which is adapted to be oscillated about said fulcrum to one side or the other by relative movement between the lever and the arm on the gimbal of the gyroscope when the aircraft tends to deviate from its course, a pair of fluid pressure supply nozzles one on each side of the two-armed lever and adjacent one side of the deflector shield, a pair of corresponding pressure receiving nozzles adjacent the other side of the shield, each in line with its respective supply nozzle, a pivoted rudder device, a pair of servomotors for turning the rudder to one side or the other and a pipe connection extending from each receiver nozzle to one of the servomotors, so that when the deflector shield swings to one side, one of the supply nozzles is uncovered and allows pressure fluid to pass into the corresponding receiver nozzle to thereby actuate one of the servomotors to actuate the rudder to correct the deviation of the aircraft.

3. An automatic controlling mechanism for the rudders of aerial torpedoes comprising in combination a constant direction non-precessional gyroscope rotor, a gimbal ring therefor, an arm projecting from the ring, a two armed lever, one end of which engages the arm on the ring, means mounting said lever for universal movement about a fulcrum, a deflector shield on the other end of said lever forming part of a sphere centered on the fulcrum of the lever, such fulcrum being so positioned in the length of the lever that the arm actuated from the gimbal ring is shorter than the arm which carries the deflector shield which is adapted to be oscillated about said fulcrum to one side or the other by relative movement between the lever and the arm on the gimbal of the gyroscope when the aircraft tends to deviate from its course either vertically or horizontally, two sets of fluid pressure supply nozzles spaced around the lever and adjacent one side of the deflector shield, two sets of pressure receiving nozzles adjacent the other side of the shield, each pressure receiving nozzle being in line with one of said supply nozzles, a pivoted rudder device, a pivoted elevator device, servomotors for actuating the rudder and elevator devices and pipe connections extending between the two sets of receiver nozzles and the servomotors, so that when the deflector shield is swung on the lever fulcrum due to deviation of the aircraft, the elevator or rudder is actuated by the shield uncovering the appropriate supply nozzle, to allow pressure fluid to pass into the corresponding receiver nozzle and actuate the rudder or elevator.

4. An automatic controlling mechanism for the rudders of aerial torpedoes comprising in combination a constant direction non-precessional gyroscope rotor, a gimbal ring therefor, an arm projecting from the ring, a two-arm pivoted lever, one end of which engages the arm on the ring, a curved deflector shield on the other end of the lever centered on the fulcrum of the lever and adapted to be oscillated about said fulcrum to one side or the other by relative movement between the lever and the arm on the gimbal of the gyroscope when the aircraft tends to deviate from its course, a pair of fluid pressure supply nozzles one on each side of the two-arm lever and adjacent one side of the deflector shield, a pair of corresponding pressure receiving nozzles adjacent the other side of the shield each in line with its respective supply nozzle, a pivoted rudder device, a pivoted controlling lever for actuating said rudder device, a pair of servomotors for actuating said controlling lever so as to turn the rudder to one side or the other, a pipe connection extending from each receiver nozzle to one of the servomotors, so that when the deflector shield swings to one side, one of the supply nozzles is uncovered and allows pressure fluid to pass into the corresponding receiver nozzle to thereby actuate one of the servomotors to actuate the rudder to correct the deviation of the aircraft, and a linkage connecting the centre part of said controlling lever with the fulcrum of said two-arm pivoted lever so that a correctional movement of the rudder in response to the movement of said shield brings about a compensating movement of the fulcrum of said two-arm pivoted lever whereby said shield is moved back into position between the nozzles previously uncovered.

5. In an automatic gyroscopic mechanism for controlling aircraft rudders as claimed in claim 1, wherein said servomotors include a pair of bellows each connected at one end to one of said pipe connections, said rudder device including a control lever on which the rudder is pivoted. a second control lever bearing on the end of both bellows and pivoted upon a floating fulcrum between the two bellows. and a cable connecting together the corresponding ends of both control levers. so that depending upon which receiver nozzle is uncovered by the deflector shield. so a charge of pressure fluid will be admitted to one or the other bellows to swing the rudder in a clockwise or anti-clockwise direction and maintain both cables taut

by the floating fulcrum, and a linkage connecting the centre part of the second control lever with the fulcrum of the two-arm pivoted lever controlling said shield, so that a correctional movement of the rudder in response to the movement of said shield brings about a compensating movement of the fulcrum of said two-arm pivoted lever whereby said shield is moved back into position between the nozzles previously uncovered.

6. An automatic controlling and stabilising mechanism for the rudders of aerial torpedoes comprising in combination a constant direction non-precessional gyroscope rotor, a gimbal ring therefor, an arm projecting from the ring, a two-arm lever, means mounted for floating movement and supporting said lever for universal movement about a fulcrum, one end of which lever engages the arm on the ring, a curved deflector shield on the other end of said lever centered on said fulcrum, such fulcrum being so positioned in the length of the lever that the arm actuated from the gimbal ring is shorter than the arm which carries the deflector shield, which is adapted to be oscillated about said fulcrum to one side or the other by relative movement between the lever and the arm of the gimbal of the gyroscope when the aircraft tends to deviate from its course either vertically or horizontally, two sets of fluid pressure supply nozzles spaced around the lever and adjacent one side of the deflector shield, two sets of pressure receiving nozzles adjacent the other side of the shield, each pressure receiving nozzle being in line with one of said supply nozzles, a pivoted rudder device, a pivoted elevator device, servomotors for actuating the rudder and elevator devices, and pipe connections extending between the two sets of receiver nozzles and the servo motors, whereby as the deflector is swung on the fulcrum of the lever due to deviation of the aircraft, the elevator or the rudder is actuated by the shield uncovering the appropriate supply nozzle to allow pressure fluid to pass into the corresponding receiver nozzle and actuate the rudder and the elevator, the two-arm lever engaging the arm on the gyroscope gimbal frame through a universal joint so that neither the action nor the mounting of the lever will exert any bias which may otherwise cause precessional movement of the gyroscope.

WALTER GORDON WILSON.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,136,666	Gardner	Apr. 20, 1915
1,335,055	Hedenstrom	Mar. 30, 1920
1,887,335	Sperry	Nov. 8, 1932
2,007,515	Wunsch et al.	July 9, 1935
2,047,922	Seligmann	July 14, 1935
2,099,808	Havill	Nov. 23, 1937
2,100,934	Berges	Nov. 30, 1937
2,104,627	Von Manteuffel	Jan. 4, 1938
2,250,344	Alkan	July 22, 1941
2,264,559	Wood et al.	Dec. 2, 1941
2,310,954	Hodgman	Feb. 16, 1943
2,330,815	Dunajeff	Oct. 5, 1943
2,339,011	Gurney	Jan. 11, 1944
2,341,644	Moller et al.	Feb. 15, 1944
2,369,652	Avery	Feb. 20, 1945