

Aug. 29, 1950

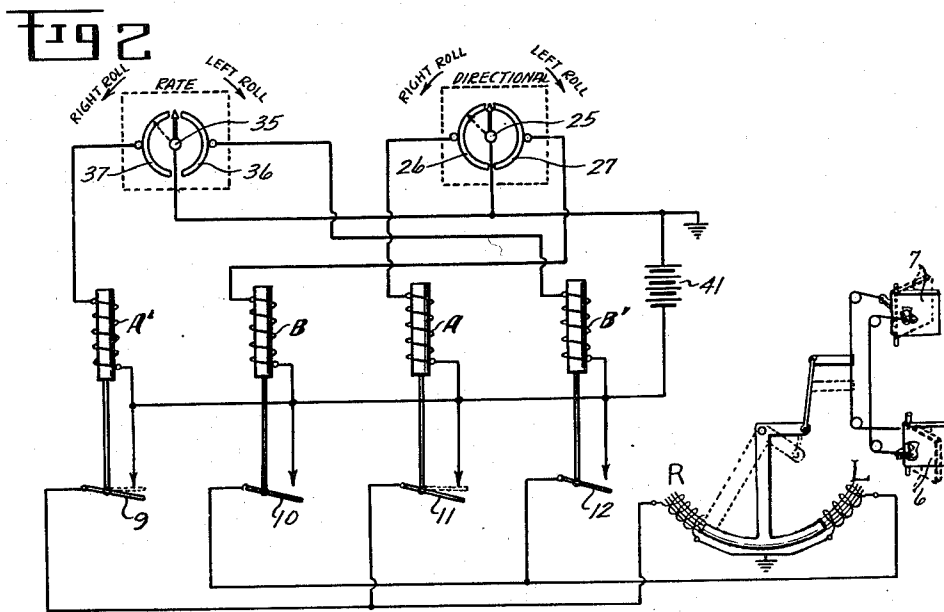
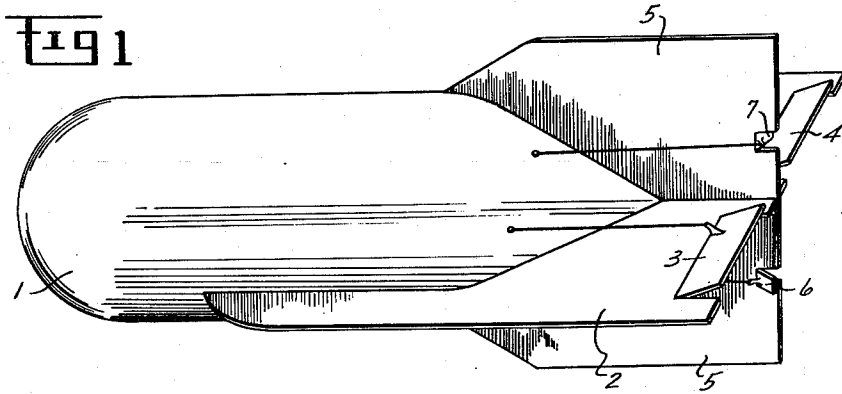
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2,520,665

GYROSCOPE CONTROL DEVICE FOR BOMBS

Filed Jan. 7, 1946

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

Fig 3

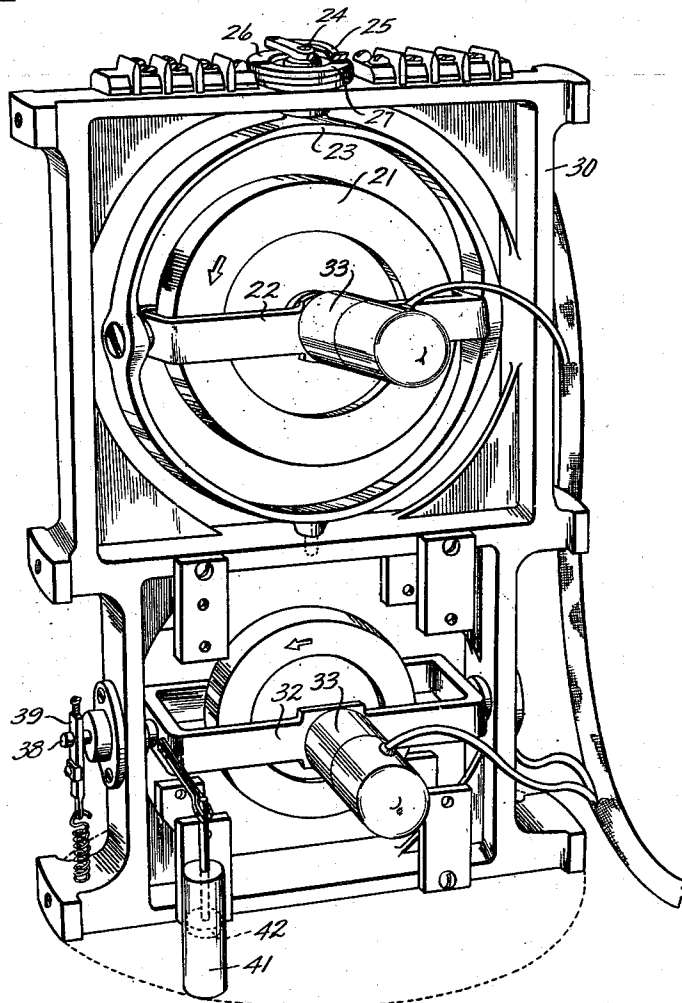
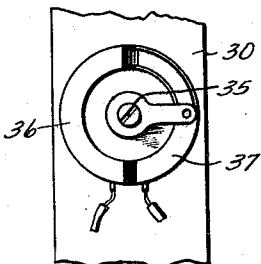


Fig 4



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2,520,665

GYROSCOPE CONTROL DEVICE FOR BOMBS

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the Secretary of War

Application January 7, 1946, Serial No. 639,686

6 Claims. (Cl. 102-3)

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The invention described herein may be manufactured and used by or for the Government for governmental purposes without payment to me of any royalty thereon.

This invention relates to high angle bombs and particularly to such bombs of the variety which are remotely controlled during the flight to change the downward course thereof either for the purpose of correcting errors and insuring the striking of a selected target or to permit release of the bomb from any part of an area greater than that within which release is normally possible if the bomb is to strike the target. Such bombs may be guided by setting the control surfaces such as the elevators and rudders, prior to release of the bomb, rather than by a remote control radio mechanism or the like during the downward flight of the bomb. In either event, however, in order to insure a controlled flight in accordance with the setting of the control surfaces, it is essential that there be no rotation of the bomb about its longitudinal axis. Various factors which tend to produce such rotation and to interfere with the accuracy of this type of bomb, are the asymmetry of the bomb, difficulty in releasing the bomb without imparting some rotative force thereto, and wind effects on the bomb.

An object of my present invention, therefore, is to provide mechanism for imparting an automatic, positive, corrective and restorative force to such bombs during the flight thereof whenever rotative deviation in either direction from the normal intended attitude of flight takes place.

Another important object of the invention is to provide means of the indicated character employing adjustable ailerons incorporated in the tail surface of the bomb, together with automatic control means whereby such ailerons are moved in response to rotative deflection of the bombs, movement of the ailerons being in a direction to cause corrective rotation of the bomb in the opposite direction to a predetermined reference position.

A further object is to provide control means such that if the rate of recovery of the bomb from an angular attitude representing a deviation from the normal or predetermined attitude affords a predetermined value, the ailerons will return to normal while the bomb continues to rotate toward the normal attitude.

A still further object relates to that last stated object and the provision of a main gyroscope device having a rotor with its rotative axis horizontal and perpendicular to the path of the bomb and arranged to effect corrective movement of

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the ailerons, while a smaller rate gyroscope is similarly mounted to limit the rate of recovery of the bomb.

Other objects and advantages will become apparent from the following description taken in connection with the accompanying drawings in which like reference characters refer to like parts in the several figures.

Fig. 1 is a perspective view of a dirigible bomb provided with flight corrective means constructed in accordance with the present invention;

Fig. 2 is a schematic wiring diagram of the principal electric control circuits and the flight rotative control surfaces, gyroscopes and servomotor means being illustrated diagrammatically;

Fig. 3 is a side view in perspective of my double gyroscope assembly utilized in stabilizing the bomb about its longitudinal rotative axis; and

Fig. 4 is a fragmentary side view illustrating the rate gyroscope pick off control contact members.

Referring to the drawings it will be observed that the bomb body 1 as shown in Fig. 1 is provided with a flight control surface 2 having movable elevators 3 and 4 hinged near the trailing edge thereof. If lateral or azimuth steering control is desired, it will be understood that the flight surface 2 must move in a vertical plane. Control of rolling tendencies of the bomb to insure maintenance of the indicated plane of movement of the bomb without rotative departure is effected by adjustable flight control surfaces or ailerons 6 and 7 hinged in the transverse control surface 5. The ailerons 6 and 7 are movable in opposite directions in response to the operation of a gyroscope control system and servomotor means hereinafter to be described. Remote directional control of the bomb may be effected by operation of the elevators 3 and 4 in any conventional manner. The mechanism for accomplishing this control forms no part of the present invention and accordingly will not be described, since it may take any of the plurality of forms as will be recognized by those skilled in the art.

The mounting and releasing means for the bombs, not shown, requires that the control surface 2 be supported in a horizontal position in the bomb bay of the aircraft carrying the bomb. It is, therefore, necessary to release the bomb with the control surface 2 in horizontal position and the control system is required to turn the surface 2 to a vertical or substantially vertical position as the nose of the bomb falls from its forwardly directed horizontal position in the flight

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path of the aircraft to a more steeply inclined angle of glide or fall.

Referring to Fig. 3, the double gyroscope assembly is illustrated as removed from the bomb with the spin axes of the gyroscopes in their relative position during the glide or fall of the bomb. This assembly includes an upper or directional gyroscope and the lower or rate gyroscope with their spin axes mounted for rotation in the same plane. Each of the gyroscope rotors is rotated constantly while the bomb is in free flight by a small electric motor 33 mounted on the inner gimbal of each. When the assembly is mounted in a bomb a vertical line diametrically projected from both rotor wheels centers in the plane of the wheels and lies on the longitudinal axis of the bomb. Prior to launching, the directional gyroscope wheel 21 rotates about a horizontal lateral axis across the flight path of the bomb, the inner gimbal member 22 being rotatable about a lateral axis, and the outer gimbal member 23 being rotatable about the longitudinal axis of the bomb. The upper pivot shaft 24 for the outer gimbal member 23 extends through the top of the frame member 30 in suitable bushings, and has a radial contact arm 25 secured thereto, adapted to selectively make electrical contact with either of a pair of spaced semi-circular insulated contact segments or plates 26 and 27 forming a split contact ring with the ends separated and insulated from each other. When the upper gyroscope rotor 21 is in the plane of the supporting frame 30, as shown in Fig. 3, the switch arm 25 rests on the insulated portion intermediate the ends of the contact plates, but rotation of the outer gimbal 23 to the left or right from this predetermined reference position will cause the switch arm 25 to contact the corresponding electrical contact segments 26 or 27. It will be understood that after launching, the bomb turns substantially 90° and continues to travel with both inner gimbal axes across the flight path of the bomb.

The smaller, or rate gyroscope, is mounted in the lower portion of the frame 30 by means of the single rate gimbal member 32, trunnioned in the frame with both of its end journal shafts extending through the sides of the frame. The right-hand trunnion, or pivot member, as viewed in Figs. 3 and 4 has a contact or switch arm 35 secured thereto, adapted to make electrical contact with a contact segment 36, or a contact segment 37 of a split contact ring, the ends of the segments being spaced and insulated from each other, similar to the contact ring associated with the directional gyroscope previously described, but the spacing between the ends of the contact segments 36 and 37 is greater than the end spacing of the segments 26-27. This wider spacing permits a limited angular movement of the switch arm 35 without closing either of the electrical circuits through the segments 36, 37 of the split contact ring. The left-hand trunnion 38 of the rate gimbal carries a spring tensioned torque arm 39 secured thereto, to provide a restoring torque tending to constantly center the gyroscope and determine the relative degree of precession of the rate gyroscope with respect to the rotative departure of the rate gimbal 32 incident to rotation of the support 30 by the bomb and prevent closure of either of the contacts 36 or 37, except when the rate precession due to rotation of the bomb exceeds a predetermined degree.

A dash-pot comprising a cylinder 41 and piston

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42 is provided, the piston being connected to an arm projecting from the gimbal 32 constitutes a dash-pot tending to dampen the oscillation of the rate gyroscope and reduce hunting.

As diagrammatically illustrated in Fig. 2, left and right solenoids L and R are provided to actuate the ailerons 6 and 7 oppositely in one direction or the opposite direction to cause application of right or left rotative torque to the bomb about its longitudinal axis. A battery 41, illustrated in the right-hand portion of the Fig. 2, is adapted to be connected to the solenoids L and R through the directional gyroscope contacts 26 or 27 whenever the bomb commences to rotate in one direction or the other about its longitudinal flight axis, the correct solenoid being energized to correct the rotation to normal; that is, to move the ailerons 6 and 7 in such directions as to apply a corrective torque in the direction opposite to the direction of rotation of the bomb. For example, it will be noted from the circuit connections as illustrated that rotation of the directional gyroscope radial switch arm 25 to the right as viewed in Fig. 2 incident to a left-hand roll of the bomb, will contact the contact plate 27, closing the circuit to relay B, closing solenoid contact arm 10, energizing the work solenoid L of the servomotor device, while movement of the switch arm 25 to the left, incident to a right roll, would contact the segment 26, energizing the relay A, and through contact 11, closed by the relay A, energize work solenoid R, setting the flight control surfaces 6 and 7 to oppose the roll. Roll in either direction, therefore, causes closure of one of the contacts 27 or 26 with arm 25 and therefore results in corrective movement of the ailerons to a position to cause application of reverse torque to reverse the roll of the bomb.

The electrical connections to the rate of turn gyroscope as illustrated are such as to close the circuit to the left or right solenoid L or R, actuating the control surfaces 6 and 7 to oppose the bomb rotation from neutral position which precessed the rate gyroscope, or to return the aileron flight control surfaces 6 and 7 to their neutral position when the rate of return of the bomb toward its neutral position exceeds a predetermined rate. Thus, during return of the bomb toward its neutral position, if the correcting torque produced by the ailerons results in an angular return velocity in excess of the predetermined return torque that is necessary as determined by the rate of tilt determining spring of the rate gyroscope, for example, in excess of 5 degrees per second, which also involves the amount of space between the rate gyroscope switch contact segments 36 and 37, the ailerons' positions will be returned to neutral. In the first case mentioned above in which the L solenoid has been energized by a clockwise directional movement of the directional gyroscope switch arm 25, the switch arm 35 of the rate gyroscope is moved in the same direction to close a circuit through relay B, contacts 10 and 12, to actuate work solenoid L, moving the ailerons 6 and 7 to apply opposing torque to the rotation of the bomb, but if the recovery angular velocity has exceeded the predetermined rate such as that set forth of 5 degrees per second the rate gimbal arm 35 will contact segment 37, thus energizing the work solenoid R while the work solenoid L is energized by the direction gyroscope contact arm 25 and control surfaces will be moved to neutral.

If the rotational rate of the bomb from its neutral position to the right or the left is at a

rate in excess of 5 degrees per second, solenoid L or R will be energized through the corresponding relays B, B' or A, A' connected in parallel but during return to neutral after a roll, if the return rates exceed 5 degrees, then B and A' or B' and A contact will be closed and the work solenoids R and L will both be energized, and the control surfaces 6 and 7 will be moved to neutral.

It will be apparent that the roll control system described is not limited to a bomb having control surfaces of the shape and proportion shown in Fig. 1. Various arrangements might be used, such as one including a movable rudder in addition to the elevator. The gyroscope unit has been built and operated with gyroscope wheels which are driven either by electric motors, or by an air jet. The principal feature of the invention is the use of a directional gyroscope and a rate gyroscope in combination to produce a device which can hold an orientation of a flight body about its flight axis without performing excessive hunting. A secondary feature of interest, primarily in high angle bombing, is the positioning of both gyroscopes, so that their axes of rotation are perpendicular to the plane of bomb trajectory.

I claim:

1. A gyroscope flight attitude control apparatus for a dirigible bomb having an adjustable flight control surface for counteracting the rate and direction of rotation of the bomb about its longitudinal axis from a predetermined flight attitude position and reversible servomotor means for actuating said flight control surface, during the descent of a bomb; said flight attitude control apparatus comprising a gyroscope support mounted on the bomb having a longitudinal axis disposed parallel to the longitudinal axis of the bomb, inner and outer gimbal members carried by said support with their tilting axes disposed perpendicular to each other, with the outer gimbal axis disposed parallel to the longitudinal axes of the support and bomb, electrical pick off control means between the support and the outer gimbal comprising two substantially semi-circular contact members on the support disposed about said outer gimbal axis and with their ends spaced from each other and in an insulated relation, a contact arm carried by the outer gimbal with its free end disposed between the adjacent ends of the semi-circular contact members for cooperative contacting engagement with either one or the other of said semi-circular contact members incident to tilt of the outer gimbal from a predetermined reference position, a rotor rotatably carried by said inner gimbal with the spin axis thereof disposed transverse to the direction of travel of the bomb, a rate gyroscope including a gimbal carried by said support having its tilt axis disposed transverse to the direction of travel of the bomb and transverse to the outer gimbal tilt axis, a power driven rotor carried by said rate gyroscope gimbal on a spin axis disposed perpendicular to the rate gyroscope gimbal tilt axis and perpendicular to the longitudinal axis of the bomb, yieldable tilting rate determining means between the rate gimbal and the support, electrical pick off contact means between the rate gyroscope gimbal and the support comprising two semi-circular contact plates fixed in insulated end to end spaced relation concentrically about the rate gimbal tilt axis, and a contact arm on the rate gimbal disposed between the ends of said spaced rate gyroscope semi-circular plates when the rate gimbal is in a predetermined reference position, for contacting en-

gagement with one or the other of said rate gyroscope plates incident to tilting movement of the rate gimbal in either direction from said predetermined reference position due to a rate of roll of the bomb in excess of a predetermined rate and relay means connected between each of the contact plates and the servomotor means for actuating said servomotor in one direction when said outer gimbal and rate gimbal contact arms are moved in one direction and to neutralize actuation of the servomotor means when said contact arms are moved relative to each other in the opposite direction.

2. A flight attitude control device, for a flight body having a longitudinal flight axis and a tendency to roll about said flight axis from a predetermined reference position and including adjustable rotation control surfaces thereon for opposing said roll tendencies, and reversible servomotor means carried by the body for actuating said surfaces; said flight attitude control device comprising a support mounted on said flight body, having a longitudinal axis disposed parallel to the longitudinal flight axis of the body, an outer gimbal rotatable on said support on a tilt axis disposed parallel to the support axis, an inner gimbal carried by said outer gimbal having a tilt axis disposed perpendicular to the outer gimbal tilt axis, a power driven rotor carried by the inner gimbal having its spin axis disposed in perpendicular relation to the outer gimbal tilt axis and perpendicular to the longitudinal axis of the support, spaced semi-circular contact members fixed on the support, surrounding the outer gimbal tilt axis, a contact arm carried by said outer gimbal with a contact end disposed between the spaced ends of the semi-circular contact members when the outer gimbal is in a predetermined reference position on the support and relatively movable by the outer gimbal incident to roll of the support about its longitudinal axis in either direction from said reference position to contact one or the other of said semi-circular contact members, a rate of roll determining gyroscope tiltable on said support, having a rate gimbal with its tilt axis disposed perpendicular to the outer gimbal tilt axis and perpendicular to the longitudinal axis of the support and a power driven gyroscope rotor mounted in said rate gimbal with its spin axis disposed perpendicular to the rate gimbal axis and perpendicular to the longitudinal axis of the support and perpendicular to the outer gimbal tilt axis when the rate gimbal is in a predetermined reference position on the support, said rate gimbal being tiltable in one direction or the other from its reference position incident to precession of the rate rotor spin axis in one direction or the other when the support is rolled about its longitudinal axis in one direction or the other from or toward its reference position in excess of a predetermined rate, spaced semi-circular contacts fixed on said support around said rate gimbal tilt axis, a contact arm carried by said rate gimbal having a contact end disposed between the spaced ends of said rate gyroscope contact plates for contacting engagement with one or the other of said rate gyroscope contact plates, incident to a predetermined degree of tilt of said rate gimbal in one direction or the other from said predetermined reference position, incident to precession of the rate gyroscope spin axis in one direction or the other caused by rotation of the body about its longitudinal axis, and electrical controlling circuits connecting the semi-circular contact

plates together which are engageable by the rate and outer gimbal contact arms during the time when the support is rotating away from its reference position in one direction in excess of a predetermined rate, and electrically connecting the semi-circular contacts together which are engageable by the rate and outer gimbal contact arms during the time when the support is rotated from said initial reference position in the opposite direction in excess of a predetermined rate, an electrical circuit connection between the rate and outer gimbal contact arms, and electrical operating connections between said electrically connected pairs of semi-circular contact plates and the servomotor for respectively energizing said servomotor in reverse directions, and a common power supply connection between said servomotor and said electrical interconnection between the contact arms.

3. A gyroscope flight control device for a flight body having a longitudinal flight axis and a tendency to roll about said flight axis and servomotor actuated flight attitude adjusting means; said flight control device comprising a support carried by the body having a longitudinal axis disposed parallel to the flight axis of the body, a stabilizing gyroscope gimballed on the support for universal freedom with its tilting and rotating center on the longitudinal axis of the support and the rotor spin axis disposed for tilting movements in planes passing through the said longitudinal axis of the support, said spin axis being initially disposed in a predetermined plane at an angle to the longitudinal axis of the support, spaced circuit controlling electrical pick-off contacts between the support and the stabilizing gyroscope gimbal means, selectively energizable by angular movement of the said gyroscope rotor spin axis in either direction about said longitudinal axis of the support from said initially disposed position, a rate gyroscope tiltably gimballed on said support having its spin axis in an initially disposed perpendicular reference position to the longitudinal support axis and tiltable in a plane extending through the longitudinal axis of the support, at right angles to the aforesaid rate gyroscope tilt axis, whereby rotation of the support in either direction precesses the said rate gyroscope spin axis in either direction in a plane passing through said longitudinal support axis, resilient degree of precession to rate of turn control means connected between the rate gyroscope gimbal and the support for determining the degree of tilting precession of the rate gyroscope spin axis incident to predetermined rates of rotation of the support about the longitudinal support axis, spaced electrical contact members between the support and said rate gyroscope gimbal means arranged for selective contact, incident to a predetermined degree of tilting precession of the rate gyroscope and rate gimbal from the initial rate gyroscope spin axis reference position, caused by rotative displacement of the support about the support axis in excess of a predetermined rate of rotation, electrical connections between said stabilizing gyroscope circuit closing contacts and said rate gyroscope circuit closing contacts connecting said spaced stabilizing and rate gyroscope contacts in parallel, comprising two separate servomotor energizing circuits connected to the servomotor for reverse operation thereof, whereby rotation of the support about said longitudinal axis away from the initial reference position in one direction or the other, in excess of a predetermined rate energizes one

or the other of said servomotor energizing circuits, and rotation of said support from the aforesaid rotatably displaced position toward said predetermined position, in excess of a predetermined rate, energizes both of said servomotor energizing circuits.

4. In a flight body having a longitudinal flight axis and a tendency to rotate about said axis from a predetermined flight attitude position, flight rotation means carried by the body for rotating the same about its longitudinal flight axis, reversible servomotor means carried by the body having separate electrical energizing circuits for reversely actuating the servomotor energizing means, a pair of servomotor energizing relays having circuit closing contacts connected to one of the servomotor energizing circuits for actuating the servomotor in one direction, a second pair of servomotor energizing relays having circuit closing contacts connected to the other servomotor energizing circuit for actuating the servomotor in the reverse direction, a free gyroscope gimballed on the body having an outer gimbal with its tilt axis parallel to the longitudinal flight axis of the body, electrical pick-off contact means between the outer gimbal and the body comprising a pair of end to end spaced contacts and a relatively movable single contact member disposed between the spaced ends of the pair of contacts when the outer gimbal is in a predetermined reference position on the body and movable incident to relative movement between the outer gimbal and body, an energizing circuit connecting each of said spaced contacts aforesaid to one relay of each of the two pairs of relays, a rate gyroscope carried by the body having its tilt axis disposed in a predetermined reference position transverse to the longitudinal axis of the body and a rate gyroscope rotor carried by the rate gimbal with its spin axis transverse to the rate gimbal and outer gimbal tilt axes, yieldable rate determining means connected between the rate gimbal and the body for determining the degree of precession of the rate gyroscope rotor spin axis to the rate of rotation of the body about its longitudinal axis, rate gyroscope electrical pick-off contact means between the rate gimbal and the body comprising a pair of end to end spaced rate gyroscope contacts and a single rate gyroscope contact member carried by the body and the rate gimbal with the single rate gyroscope contact member disposed intermediate the ends of the spaced rate gyroscope contacts when the rate gimbal is in its reference position, and relatively shiftable incident to the tilting displacement between the rate gimbal and the body, the ends of said spaced rate gyroscope contacts being spaced apart a predetermined distance to permit a predetermined degree of tilting precession of the rate gimbal before contacting relation is established between the single contact member of the rate gyroscope and either of the spaced rate gyroscope pick-off contacts, and an electrical circuit connection between the remaining one of each of the pairs of relay devices and each of the spaced rate gyroscope contacts, and a common relay energizing return circuit connecting the single contact members of the outer and rate gyroscopes and the two pairs of relays.

5. In a flight attitude control device, a support having a longitudinal flight axis and a tendency to rotate from a predetermined flight attitude position about said flight axis, a free gyroscope gimballed on said support with its rotor spin axis transverse to the said flight axis, a pair of

spaced electrical servomotor pick-off contact means and a movable contact therefor carried by the support and the free gyroscope gimbal means, said pair of spaced contact means being selectively energizable by the movable contact by rotative departure of the free gyroscope gimbal means in either direction from a predetermined reference relation to the support incident to rotation of the support from its flight attitude position in either direction about its flight axis, a pair of servomotor energizing and reversing relays each connected to one of said spaced free gyroscope gimbal pick-off contact means, a rate gyroscope carried by the support with its spin axis transverse to the longitudinal flight axis of the support, yieldable rate of rotation of the support determining means connected between the support and rate gimbal yieldably maintaining the rate gimbal in a predetermined reference position relative to the flight axis of the support, a pair of spaced rate gimbal electrical pick-off contact means and a movable rate contact operable between the rate gimbal and the support, said spaced rate gimbal contacts being selectively engageable with the movable rate contact by tilting displacement of the rate gimbal beyond a predetermined degree of tilt in either direction incident to a predetermined rate of rotation of the support about its flight axis, and a second pair of servomotor reversing and energizing relays each connected to one of said spaced rate gyroscope electrical pick-off contacts, whereby rotation of the support away from its predetermined flight attitude reference position at a rate lower than the aforesaid predetermined rate of rotation energized one of said first pair of relays through the pick-off contacts between the support and the free gimbal means, and rotative displacement in the same direction at a rate exceeding said predetermined rate of rotation also energizes a relay in the second mentioned pair of relays through the pick-off contact means between the support and rate gimbal, and return rotation of the support from its displaced relation toward said flight attitude position at less than said predetermined rate of rotation interrupts the rate pick-off contact relation to said relay of the second pair of relays, and return rotation of the support about its flight axis toward said predetermined flight attitude reference position in excess of said predetermined rotational rate energizes said rate gimbal pick-off contact means to energize the other relay of said second pair of relays.

6. A flight attitude control device, for controlling the flight attitude of a flight body having a predetermined flight axis and a flight attitude reference position and adjustable flight attitude control means carried by the flight body for controlling the flight attitude of the body about its predetermined flight axis and reversible servomotor means carried by the flight body and connected to the adjustable flight attitude control means for adjustment thereof to adjust the flight attitude of the flight body; said flight attitude control device comprising a support fixedly carried by the flight body having a predetermined flight attitude axis disposed parallel to the predetermined flight axis of the body, an outer gimbal rotatably carried by the support on an axis parallel to the predetermined flight attitude axis of the support, an inner gimbal tiltably carried

by the outer gimbal on an axis perpendicular to the outer gimbal tilt axis, a power driven gyroscope rotor journaled on the inner gimbal perpendicular to the inner gimbal tilt axis, electrical servomotor pick-off control means connected to the reversible servomotor means and including a pair of spaced electrical contacts and an intermediate relatively movable contact between the support and outer gimbal, said intermediate contact and one of said spaced contacts being engageable for actuation of the reversible servomotor means in one direction incident to rotative displacement between the outer gimbal and support in one direction from a predetermined reference relation therebetween, and engageable with the other of said spaced contacts by rotative displacement between the outer gimbal and the support from the said reference relation in the opposite direction to energize and actuate said reversible servomotor means in the opposite direction, a rate gyroscope carried on the support comprising a rate gimbal tiltably journaled on the support on a tilt axis perpendicular to the outer gimbal tilt axis, a power driven rate gyroscope carried by the rate gimbal with its spin axis perpendicular to the rate gimbal axis, yieldable rate of roll determining means connected between the support and the rate gimbal for yieldably maintaining said rate rotor spin axis in a predetermined flight axis reference position perpendicular to the outer gimbal tilt axis, servomotor electrical pick-off control means connectible with the reversible servomotor means including a pair of spaced electrical contacts and an intermediate relatively movable contact between the rate gimbal and support, said last mentioned intermediate contact and one or the other of the last mentioned spaced contacts being engageable for selective energizing connection with the reversible servomotor means aforesaid incident to tilting displacement of the rate gyroscope spin axis beyond a predetermined degree of tilt in either direction from said rate gimbal reference position to energize the servomotor means for operation in the same direction as the energization thereof by the outer gimbal servomotor pick-off control means when the outer gimbal is displaced away from its flight attitude reference position by rotation of the body about its flight axis, and to reversibly energize said servomotor means by engagement between the last mentioned intermediate contact and the other of the rate gimbal spaced contacts in opposition to the energization of the servomotor means by said outer gimbal pick-off control means when the outer gimbal is relatively returned toward its reference position by return rotation of the support toward its flight attitude reference position at a rate in excess of the predetermined are as determined by the rate gyroscope.

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