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Delayed Action Reversing Switch

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WPI Class of 1908

May 16, 1939. R. H. GODDARD 2,158,181

DELAYED ACTION REVERSING SWITCH

Original Filed Nov. 9, 1936 3 Sheets–Sheet 1

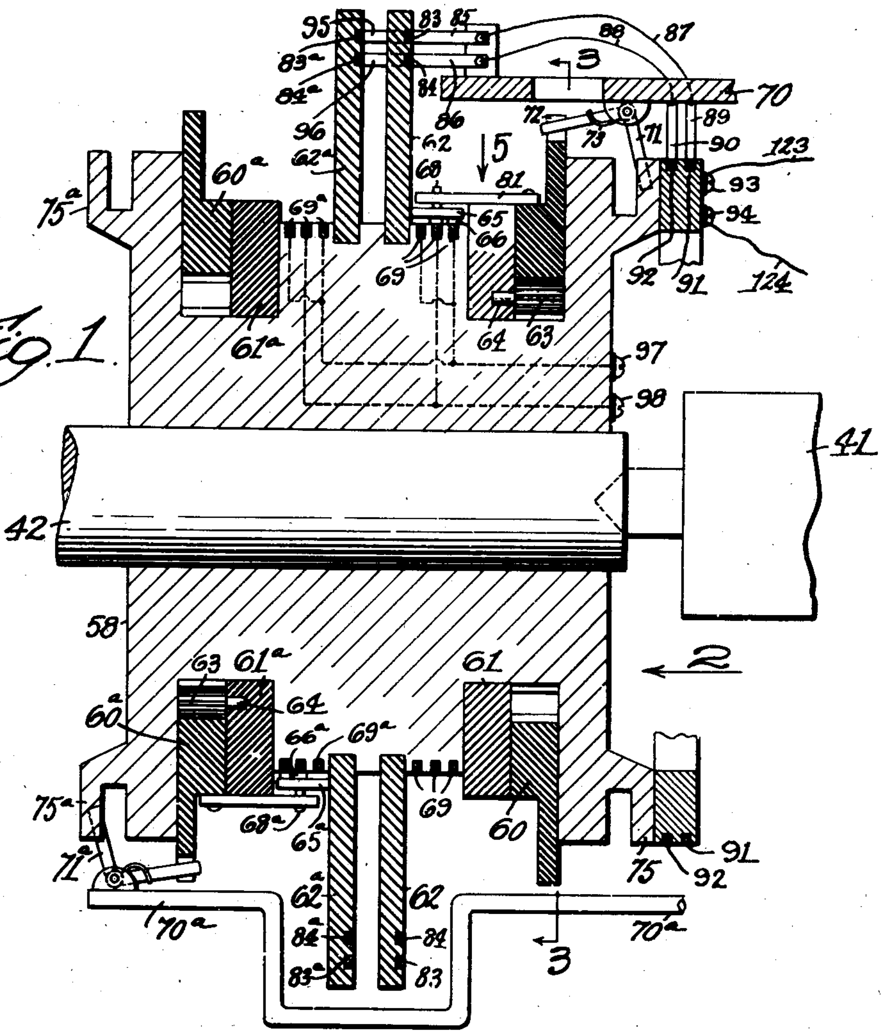

Fig. 1.

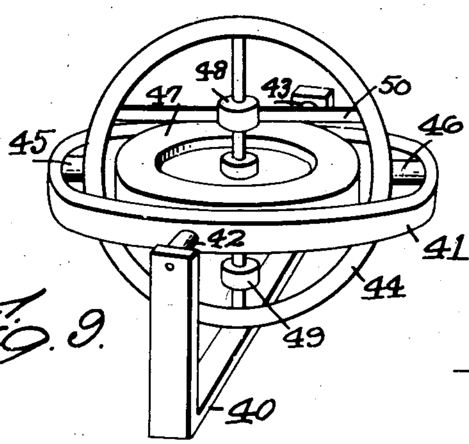

Fig. 9.

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DELAYED ACTION REVERSING SWITCH

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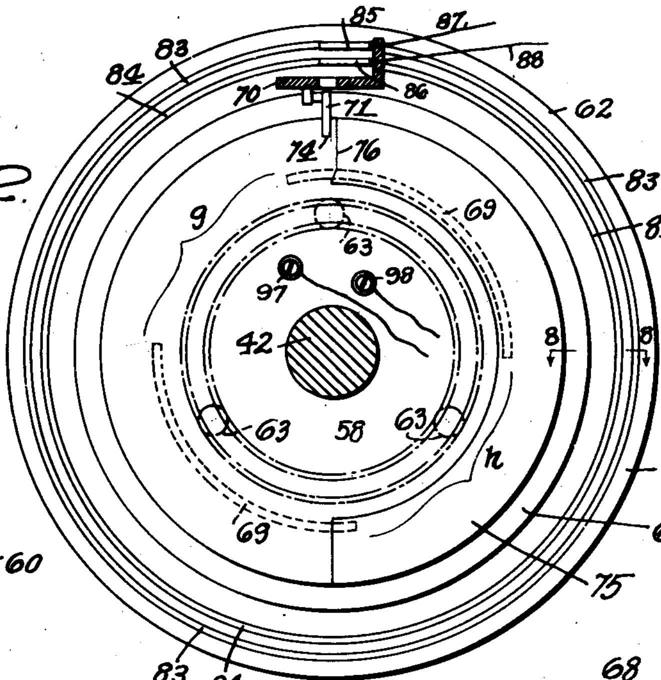

Fig. 2.

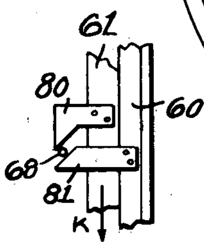

Fig. 5.

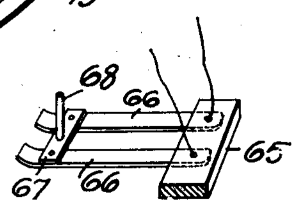

Fig. 4.

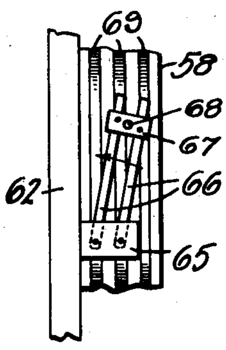

Fig. 6.

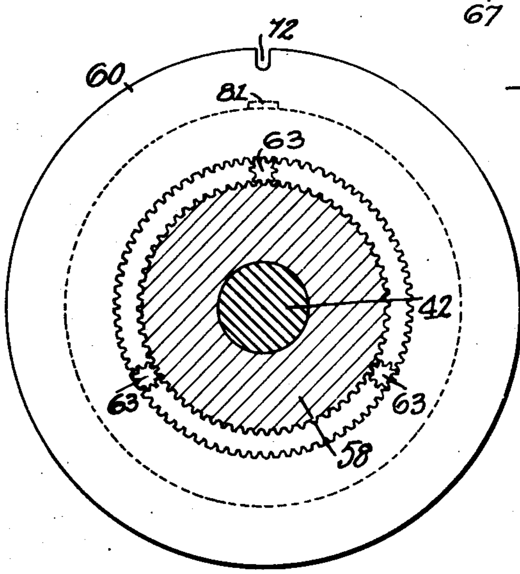

Fig. 3.

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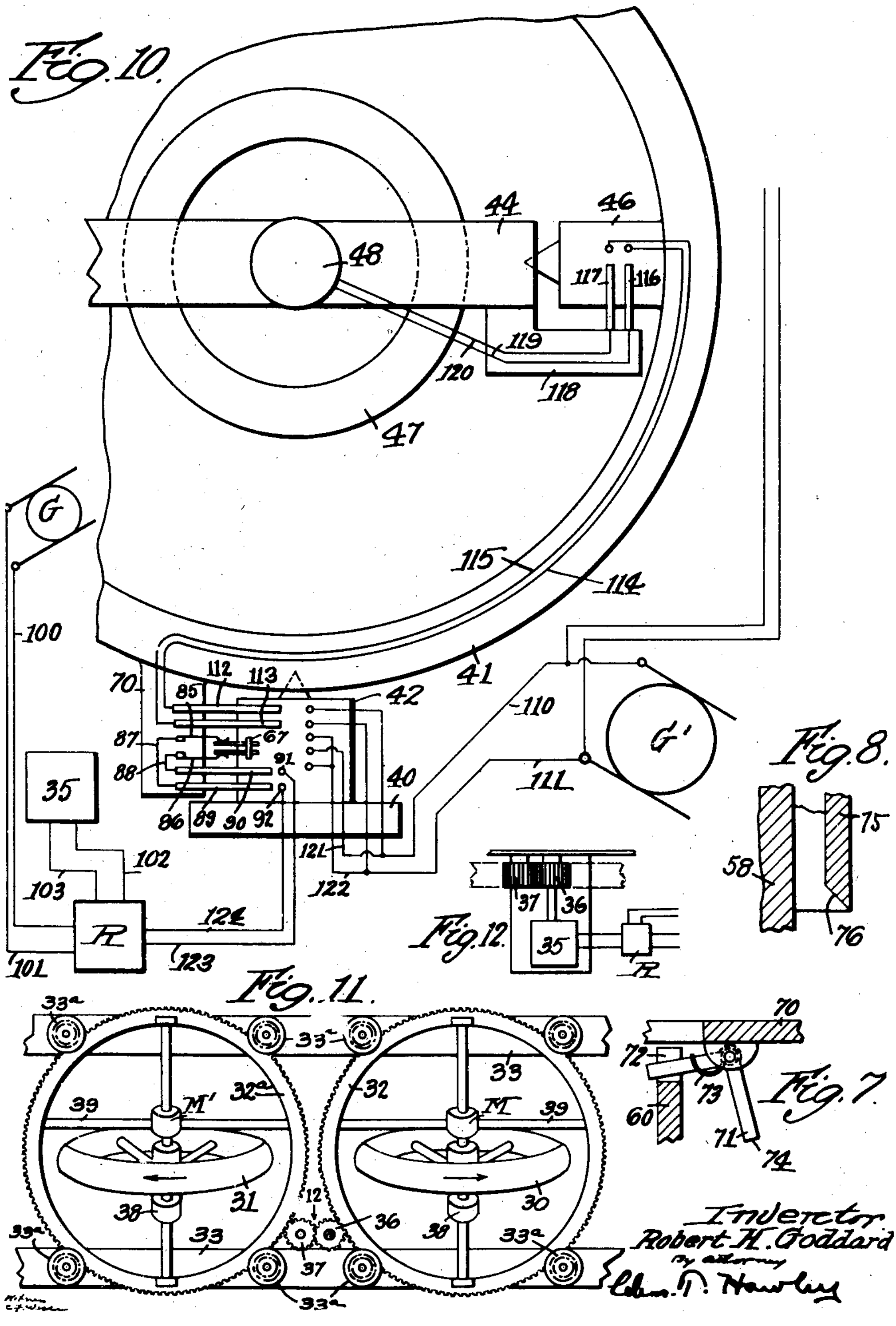

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UNITED STATES PATENT OFFICE

2,158,181

DELAYED ACTION REVERSING SWITCH

Robert H. Goddard, Roswell, N. Mex.

Original application November 9, 1936, Serial No. 109,964. Divided and this application July 10, 1937, Serial No. 153,009

8 Claims. (Cl. 200—33)

This application is a division of my prior application Serial No. 109,964, filed November 9, 1936 on Gyroscopic steering apparatus.

The present application relates to a delayed action reversing switch, fully shown and described in said original application. My improved switch is capable of general application but is particularly designed for use with flight-directing gyroscopic apparatus.

It is the general object of my invention to provide a delayed action reversing switch by which current may be caused to flow through an electric circuit in one direction for a certain period of time and may be caused to flow through said circuit in the opposite direction for another period of time but only after a predetermined neutral interval.

A further object is to provide a switch in which the reverse operating period will always be in fixed proportion to the initial operating period, regardless of the length of said initial period.

My invention further relates to arrangements and combinations of parts which will be hereinafter described and more particularly pointed out in the appended claims.

A preferred form of the invention is shown in the drawings, in which

Fig. 1 is a sectional elevation of my improved reversing switch;

Fig. 2 is an end view thereof, partly in section, looking in the direction of the arrow 2 in Fig. 1;

Fig. 3 is a sectional end elevation, taken along the line 3—3 in Fig. 1;

Fig. 4 is a perspective view of a double-pole switch;

Fig. 5 is a detail view of certain switch control parts, looking in the direction of the arrow 5 in Fig. 1;

Fig. 6 is a plan view of said double-pole switch, in association with cooperating parts;

Fig. 7 is an enlarged side elevation of a locking device;

Fig. 8 is a detail sectional view, taken along the line 8—8 in Fig. 2;

Fig. 9 is a perspective view of a double-acting pilot gyroscope with which my reversing switch may be used;

Fig. 10 is a wiring diagram for said pilot gyroscope and associated switches and apparatus controlled thereby;

Fig. 11 is a perspective view of a steering gyroscope assembly; and

Fig. 12 is a detail plan view, looking in the direction of the arrow 12 in Fig. 11.

In the development of the improved gyroscopic steering apparatus, for the control of which my improved switch is particularly designed, I make use of the known principle that a heavy ring rotating on an axis in a supporting structure and in a plane perpendicular to the axis of said supporting structure will produce a reacting force tending to rotate said supporting structure in a reverse direction, which rotation will actually take place if the supporting structure is itself mounted for free rotation.

Preferably, I provide a pair of rotating elements in each gyroscopic steering unit, which elements rotate in opposite directions about axes which are normally parallel. The two elements, thus rotating in opposite directions in the same plane, neutralize each other and, when in normal position, have no effect on the flight of the aircraft.

Such an arrangement is indicated in Figs. 11 and 12 in which rotating elements 30 and 31 are mounted in gimbals 32 and 32^a in a frame 33. So long as the parts are in the position shown in Fig. 11, the frame 33 will remain at rest. If, however, the gimbals are moved simultaneously in opposite directions to bring the rotating elements 30 and 31 to oppositely inclined positions, an angular momentum will be produced by the rotating elements, and the accompanying reactive force on the supporting frame 33 will tend to produce angular movement thereof. This reactive force is a maximum when the gimbals 32 and 32^a are each rotated 90°, but any angular displacement of the two gimbals and rotated elements simultaneously in opposed directions will produce a substantial angular reaction, which reaction increases with the angle of displacement.

The gimbals 32 and 32^a (Figs. 11 and 12) are provided with external gear teeth and are mounted for rotation on rolls or loose pinions 33^a. A motor 35 (Fig. 12) drives a pinion 36 which engages the gimbal 32, and the pinion 36 meshes with a pinion 37 which engages and drives the second gimbal 32^a.

The motor 35 is of the reversing type and constitutes means by which the gimbals 32 and 32^a may be simultaneously displaced angularly to any desired extent but always in opposed directions.

Motors M and M′ are provided for continuously rotating the gyroscope elements 30 and 31, and corresponding rotating counterbalances 38 are also provided. The non-rotating parts of the motors M and M′ are supported on cross rods or braces 38 in the gimbals 32 and 32^a.

If it is now assumed that the frame 33 is fixed in position in an aircraft and that the rotated elements are displaced, the reaction of the displaced gyroscopic elements will tend to turn the aircraft in a definite direction. If the gimbals and rotated elements are thereafter displaced in the reverse direction, the reaction will be reversed and the craft will be turned in the opposite direction.

It is thus possible to control the movements of an aircraft in vertical and horizontal planes and also about its own axis, by providing three pairs of rotating gyroscopic elements, each pair operating in perpendicularly disposed relation to the other two pairs.

If one pair of said gyroscope elements, as 30 and 31, are moved out of their normal or balanced inoperative relation by turning the supporting gimbals in opposite directions, the directing force then developed by the displaced gyroscopes will divert the aircraft from its prior path of travel and will continue to divert, turn or rotate the craft further and further from its normal path, such action continuing as long as the gyroscope elements remain out of normal or balanced inoperative position. When said elements are returned to such balanced position, the craft will continue in its new direction, unless diverted therefrom by some external force.

For a more complete description of this general method of flight control, reference is made to the original application of which this is a division.

While my improved gyroscopic apparatus in this simple form may thus be used to steer an aircraft in a desired path of travel by manual control of the steering gyroscopes, the invention is more broadly useful when associated with gyroscopic control devices or pilot gyroscopes, by the action of which an aircraft, when diverted from its path of travel by external force, will be automatically returned to its original path of travel.

For this purpose I preferably provide a double-acting pilot gyroscope such as is shown in Figs. 9 and 10, and which is adapted to control two motors, as **35**, which will each correct deviations of an aircraft from its path of travel in one plane.

Each pilot gyroscope comprises a frame **40** fixed in position in the aircraft and supporting a gimbal **41** on gimbal bearings **42** and **43**. A second gimbal **44** is mounted within the gimbal **41** on gimbal bearings **45** and **46**. A gyroscope element **47** of substantial weight is rotatably mounted in the gimbal **44** and is provided with a driving motor **48** and a rotating counterweight **49**. The non-rotating parts of the motor **48** are mounted on a cross brace **50** carried by the gimbal **44**.

Whenever the aircraft is diverted from its normal course in either of the two directions controlled by the gyroscope element **47**, said element will continue to rotate in its normal plane, but the supporting gimbals **44** and **41** will be displaced relative to each other and also relative to the fixed frame **40**, and by suitable electrical connections they will determine the operation of the motors which rotate the gimbals of the directing or steering gyroscopes controlled thereby.

When my improved gyroscopic steering apparatus is thus automatically controlled to maintain a directed flight, it operates to displace the gimbals **32**—**32a** in one of the gyroscope frames **33** in a certain way to offset a divergence in flight caused by a given external force and to prevent further divergence in this undesired direction. It is then necessary to produce an angular correction of the path of flight in the opposite direction to restore the original direction of flight. It is also particularly desirable to prevent overcorrection, which would cause an irregular, wabbling or oscillating flight.

For such automatic control, I cause a motor, as 35, to increasingly displace its associated gyroscope elements until the disturbing external force is overcome and neutralized. The flight-correcting gyroscopes then continue to rotate in their new displaced relation for a certain period, thus providing further reactive force to partially restore the craft to its original position, after which said controlling motor will be operated in the reverse direction to gradually return the flight-correcting gyroscopes to their original balanced and inoperative positions.

In order to effect the described series of operations of the steering gyroscope motor, I have devised the delayed action reversing switch shown in detail in Figs. 1 to 8 and which will now be described.

A block **58** (Fig. 1) of insulating material is fixed on the pilot gyroscope frame **40** concentric with the pivot bearing **42** of the gimbal **41**. A plurality of rings 60 and **60a**, 61 and 61a and **62** and 62a are rotatably mounted on the block **58**.

The rings **60** and 60a are provided with internal gear teeth, meshing with pinions **63** which also engage fixed external gear teeth on the block 58, and which are mounted on pivot studs 64 fixed in the adjacent ring 61 or 61a. Rotation of one of the rings 60 or 60a will cause simultaneous rotation of the corresponding ring **61** or 61a in the same direction but at one-half the speed, due to the well-known properties of planetary gears.

The rings **62** and 62a are loose on the block **58** but are held frictionally from unrestrained movement thereon. The ring **62** has a projection **65** (Fig. 6) on which are pivotally mounted a pair of contact fingers 66 (Fig. 4) forming a double pole switch **67** having an operating pin **68** secured thereto near the free ends of said fingers.

The contact fingers **66** are adapted to contact with contact rings **69** (Fig. 6) mounted on the block **58** and concentric therewith. The rings **69** are segmental only, and the ends of the rings are separated by a space indicated by the letter *g* in Fig. 2.

The switch **67** may be thrown from right to left as viewed in Fig. 6, and in both positions will make contact with the middle ring **69** and with one or the other of the outside rings. The outside rings are connected together as indicated in Fig. 1, so that movement of the switch from side to side will reverse the direction of current flow in the circuits controlled thereby.

The ring **62a** is similarly provided with a projection **65a** supporting a double pole switch similar to the switch **67** and having an operating pin **68a**, and said switch having a pair of contact fingers **66a** adapted to engage selected segmental rings **69a** having their ends spaced apart as indicated at *h* in Fig. 2.

An arm **70** (Figs. 1 and 2) is attached to the gimbal which is angularly displaceable relative to the frame **40** and block **58**. The arm **70** is provided with a bell crank **71** (Fig. 7) having a laterally extended portion normally seated in a slot **72** (Fig. 3) in the periphery of the ring **60**, so that the ring **60** is normally held in fixed angular relation to the arm 70 and its supporting gimbal.

A spring 73 (Fig. 7) normally holds the parts yieldingly in the described relation and with the depending portion 74 of the bell crank 71 in alignment with a segmental ring 75 (Fig. 8) fixed on the end of the block 58. When the arm 70 and bell crank 71 are rotated in a direction away from the end of the fixed segmental ring 75, the parts maintain the relation shown in Figs. 1 and 7 and the ring 60 is moved with the arm 70.

If the arm 70 is displaced in the opposite direction, however, the depending arm 74 engages a beveled end surface 76 (Fig. 8) of the ring 75 and is swung clockwise out of the slot 72, thus causing no movement of the ring 60.

When the parts are thus operated, however, a corresponding bell crank 71^a (Fig. 1) engages and rotates the ring 60^a in a direction opposite to the previously described movement of the ring 60. The bell crank 71^a is mounted on an arm 70^a which is fixed to the same gimbal which supports the arm 70, and the bell crank is controlled in its operation by a fixed ring 75^a, all as previously described.

The ring 61 (Fig. 5) carries a cam arm 80 fixed thereto and projecting laterally therefrom to engage the operating pin 68 of the double pole switch 67. When the gimbal which supports the arm 70 is displaced angularly in the direction indicated by the arrow *k* in Fig. 5, the rings 60 and 61 will be similarly displaced, although at different speeds, and the arm 80 will engage and shift the pin 68 to the position shown in Fig. 6.

A second cam arm 81 (Fig. 5) is mounted on the ring 60 and when moved in the reverse direction will shift the switch 67 to its opposite working position. Similar cam arms are associated with the rings 60^a and 61^a and similarly engage the pin 68^a and operate the switch fingers 66^a.

The contact fingers 66 of the switch 67 are connected to concentric bands 83 and 84 (Fig. 1) on the ring 62, which bands are engaged by contact strips or brushes 85 and 86 on the arm 70, connected by wires 87 and 88 to brushes 89 and 90 which engage commutator rings 91 and 92 mounted on an extension of the block 58 and connected to binding posts 93 and 94.

Brushes 95 and 96 are mounted on the ring 62 and are connected to the bands 83 and 84, and said brushes engage corresponding bands 83^a and 84^a on the ring 62^a, which bands are connected respectively to the two contact fingers 66^a of the lower switch. The outside segmental rings 69 and 69^a (Fig. 1) are connected to a terminal 97 on the block 58, and the middle rings 69 and 69^a are similarly connected to a second terminal 98.

The operation of the delayed action switch mechanism above described is as follows:

When the gimbal supporting the arm 70 is displaced in the direction of the arrow *k* in Fig. 5, the ring 60 is similarly displaced and the ring 61 is moved in the same direction but for one-half the distance. Such movement causes the cam arm 80 to shift the switch 67 to the position shown in Fig. 6. After having shifted the switch, the arm 80 continues to push against the pin 68, thus rotating the ring 62 with the arm 80.

The switch fingers 66 normally rest on the non-conducting portion *g* of the block 58 between the ends of the segmental rings 69, but as soon as the rotation of the ring 62 is begun, the fingers engage the selected rings 69 and complete a motor control circuit which will be hereinafter described.

The motion of the arm 70 and ring 60 and the half speed motion of the rings 61 and 62 continue until the corresponding steering gyroscope has equalized the deviating force and thus stopped the relative angular movement of the gimbal which supports the arm 70.

The steering gyroscope motor will continue to operate, still further displacing the steering gyroscopes to produce a counter-rotation of the aircraft and a like rotation of the pilot gyroscope gimbal supporting the arm 70. This will rotate the ring 60 in the opposite direction, carrying with it the ring 61 at half speed, but the ring 62 supporting the switch 67 will be held frictionally in fixed position until the pin 68 is engaged by the cam arm 81.

As the arm 81 has traveled twice as fast and twice as far as the pin 68 in the initial direction, the arm 81 will not reverse the switch 67 until half of its return movement has been completed. Thereupon the switch 67 will be reversed and will then be returned to initial position along with the ring 62.

When the switch is reversed, the control circuit of the motor which shifts the steering gyroscope is reversed and the gyroscope elements are gradually brought back to initial inoperative relation, this result being accomplished at the same time that the ring 62 is returned to its original position and the control circuit is broken by separation of the contact fingers 66 from the segmental rings 69.

If the initial movement of the arms 70 and 70^a is in the opposite direction, the corresponding parts at the left in Fig. 1 will be similarly operated to correct a deviation in the opposite direction.

The electrical circuits and connections through which my improved switch connects a pilot gyroscope to control a steering gyroscope are shown diagrammatically in Fig. 10.

The main generator or source of power G is connected through wires 100 and 101, a relay R and wires 102 and 103 to a motor, as 35, (Fig. 12) which rotates the gimbal frames 32 and 32^a of the steering gyroscope shown in Fig. 11.

A second generator G′ is connected through wires 110 and 111 to commutator rings on the gimbal bearing 42 of the double acting pilot gyroscope shown in Fig. 9. Brushes 112 and 113 are mounted on the arm 70 of the gimbal 41 and are connected by wires 114 and 115 to commutator rings on the gimbal bearing 46, which rings are engaged by brushes 116 and 117 mounted on an arm 118 on the inner gimbal ring 44. The brushes 116 and 117 are connected by wires 119 and 120 to the motor 48 which drives the constantly rotating gyroscope element 47. Through these connections the generator G′ is continuously connected to the motor 48 in every position of the pilot gyroscope and its supporting gimbals.

The generator G′ is also connected through branch wires 121 and 122 to the segmental rings 69 previously described, which rings are selectively engaged by contact fingers of the switch 67 to complete a control circuit through the brushes 85 and 86, wires 87 and 88, brushes 89 and 90, commutator rings 91 and 92 and wires 123 and 124 to the relay R previously described. Through these connections displacement of the gimbal 41 from its normal relation to the frame 40 causes the relay R to be operated in such manner as to connect the generator G to the motor **35** and thus cause rotation thereof in one direction.

For the sake of clearness, the connections through the segmental rings **69**[a] and switch **67**[a] are omitted, these being duplicates of the circuits previously described and being connected to cause the relay R to complete reverse connections between the generator G and the motor **35**, so that the motor will operate in the opposite direction.

With the connections described, it will be evident that the motor **35** which controls one of the steering gyroscopes will be operated in accordance with the displacement of the gimbal **41** relative to the supporting frame **40**, and that the operation of a second steering gyroscope will be in accordance with the displacement of the gimbal **44** relative to the gimbal **41**.

Having fully described the details of construction of my improved delayed action switch and its utility in connection with gyroscopic control apparatus, it is believed that the operation and advantages of my invention will be readily apparent. I do not wish to be limited to the details herein disclosed, otherwise than as set forth in the claims, but what I claim is:

1. A delayed action switch comprising a contact device, a first member effective to shift said device in one direction when rotated in a given direction, a second member effective to shift said device in the opposite direction when rotated in the reverse direction, and means to rotate said members in the same direction and to move one member twice as fast as the other, whereby a delayed reverse shift of said device occurs after reversal of rotation of said members.

2. The combination in a delayed action switch as set forth in claim 1, in which the contact device is mounted on a third rotatable member which is held frictionally at rest between engagements by said members.

3. A delayed action switch comprising a contact device, a rotatable member effective to engage and shift said contact device in one direction when rotated in a primary direction but ineffective to shift said device when moved in the opposite secondary direction, a second rotatable member effective to engage and shift said contact device in the opposite direction when said second member is moved in said secondary direction but ineffective to shift said contact device when moved in said primary direction, and means to move said two rotatable members simultaneously in the same direction but at substantially different speeds.

4. A delayed action switch comprising a contact device, segmental conducting rings selectively engaged by said device, a relatively fixed support for said rings, first, second and third members movably mounted on said support, said third member supporting said contact device, means on said first member to shift said device in one direction, means on said second member to shift said device in the opposite direction, means to move said first member angularly on said support, and connections between said first and second members through which said first member drives said second member in the same direction but at reduced speed.

5. A delayed action switch comprising a contact device, segmental conducting rings selectively engaged by said device and having an adjacent insulating surface on which said devices normally rest, a cylindrical and relatively fixed support for said rings, first, second and third members rotatably mounted on said support, said third member supporting said contact device, means on said first member to shift said device in one direction, means on said second member to shift said device in the opposite direction, means to partially rotate said first member on said support, and connections between said first and second members through which said first member when rotated in either direction rotates said second member in the same direction but at one-half of the speed of said first member.

6. A delayed action switch comprising a contact device, spaced segmental conducting rings selectively engaged by said device, a cylindrical support for said rings, first, second and third members rotatably mounted on said support, said third member supporting said contact device and being frictionally retarded on said support, means on said first member to shift said device in one direction, means on said second member to shift said device in the opposite direction, means to move said first member angularly on said support, and planetary gearing between said first and second members through which said first member when moved in either direction moves said second member in the same direction but at one-half the speed and for one-half the distance.

7. In a delayed action reversing switch, a cylindrical support, first, second and third members rotatably mounted on said support, a contact device on said third member, a cam arm on said second member effective to shift said device in one direction and to thereafter rotate said third member with said second member, a cam arm on said first member effective to shift said device in the opposite direction and to thereafter return said third member with said first and second members to initial position, and means to rotate said first and second members in the same direction at different speeds but in a fixed speed ratio.

8. In a delayed action reversing switch, a cylindrical support, first, second and third members rotatably mounted on said support, a contact device on said third member, a cam arm on said second member effective to shift said device in one direction and to thereafter rotate said third member with said second member, a cam arm on said first member effective to shift said device in the opposite direction and to thereafter return said third member with said first and second members to initial position, means to rotate said first and second members in the same direction at different speeds but in a fixed speed ratio, angularly movable driving means for said first member, and means to lock said driving means to said first member when said driving means is moved in one direction only.

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