

May 21, 1963

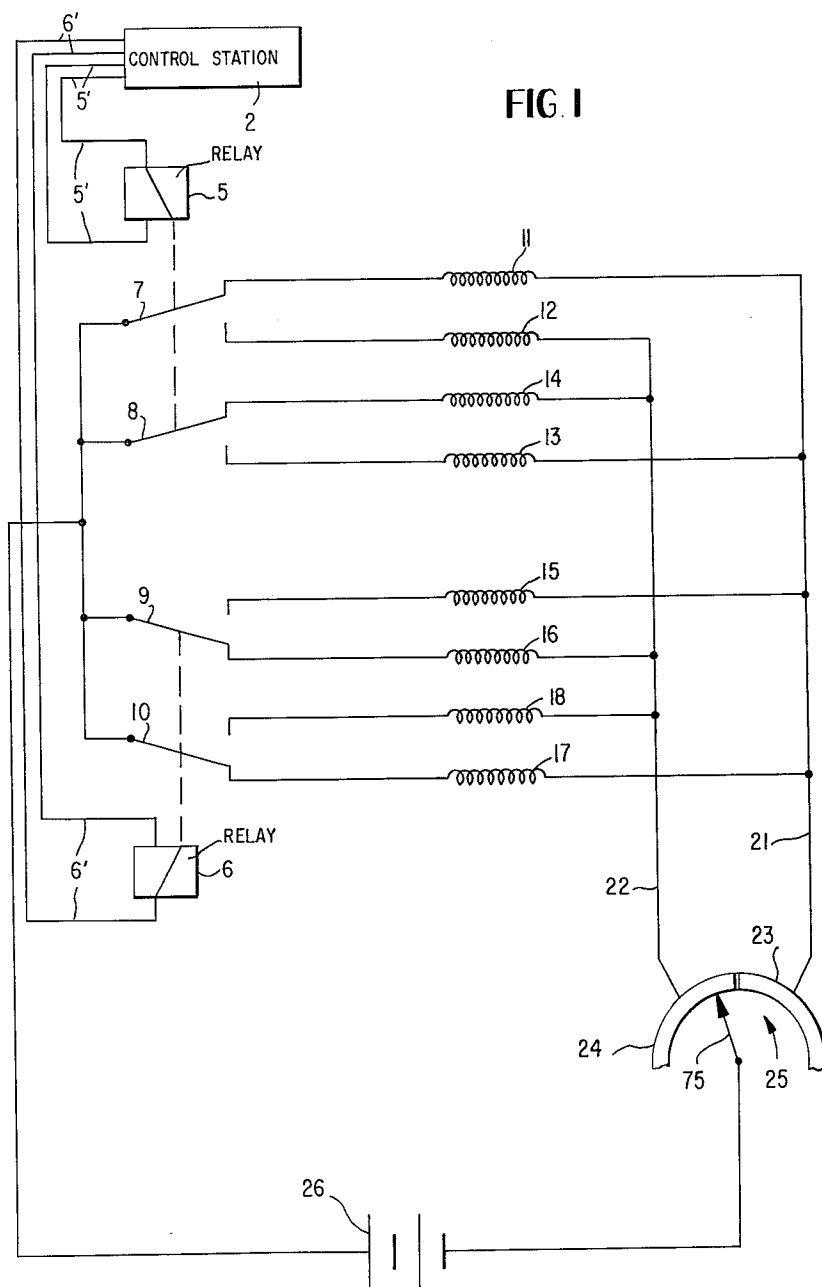
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3,090,582

REMOTE CONTROL AND STABILIZING APPARATUS

Filed Jan. 15, 1959

3 Sheets-Sheet 1



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FIG. 2

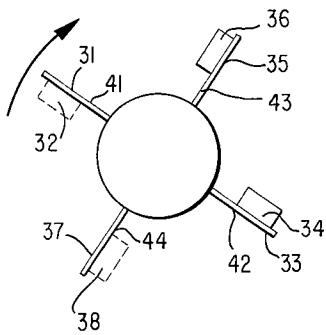


FIG. 2a

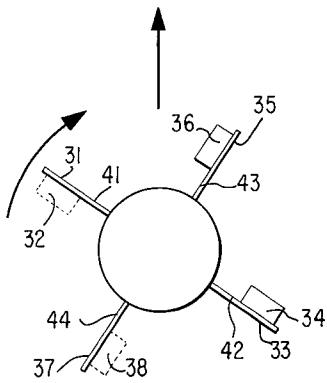
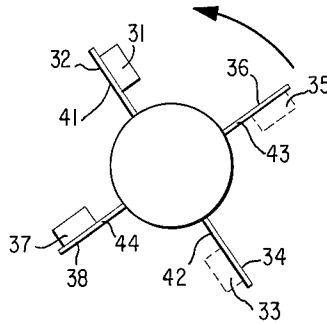


FIG. 3

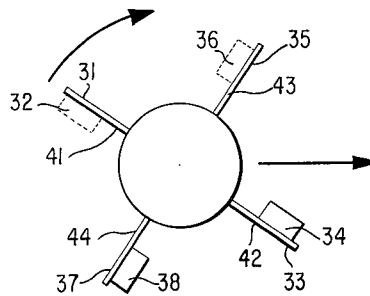


FIG. 4

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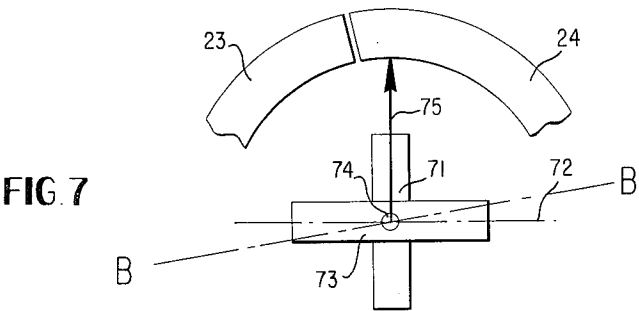
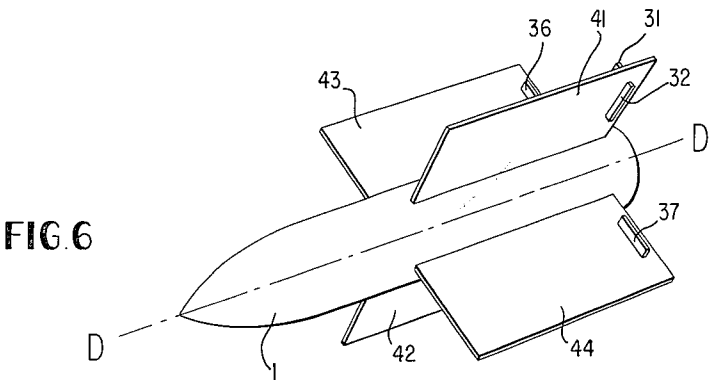
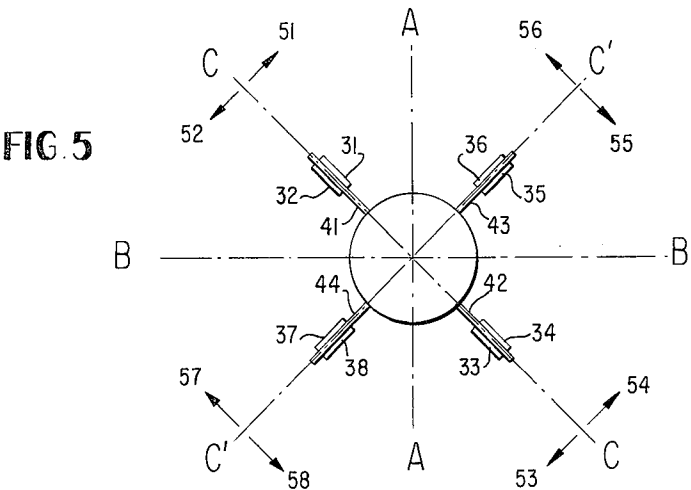
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REMOTE CONTROL AND STABILIZING APPARATUS

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3 Sheets-Sheet 3



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3,090,582

REMOTE CONTROL AND STABILIZING APPARATUS

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Claims priority, application Germany Jan. 15, 1958
12 Claims. (Cl. 244-14)

The present invention relates to an apparatus for controlling the movements of bodies traveling through air or water from a point remote from such body, and also for stabilizing the movements of such bodies which especially include aircraft, watercraft, missiles, torpedoes, and the like, and will for the purpose of describing the present invention be hereafter simply referred to as "missiles."

The required stabilization of such missiles about their longitudinal axis has in the past been produced primarily by gyroscopic apparatus mounted on such missile. Such gyroscopic apparatus act upon suitable steering devices, for example, so-called spoiler plates which are mounted on the airfoils or fins and are moved in a transverse direction into the air or water current. Such action of the gyroscopic apparatus is similar to that produced by the control impulses sent by a remote-control apparatus upon the steering means of the missile for changing its direction of travel. The operation of such spoiler plates by the steering and stabilizing means is carried out according to one known method by the separate provision of spoiler plates for steering purposes and of one or more spoiler plates for stabilizing the movements of the missile while in flight. Such separate spoiler plates for these two different purposes have the disadvantage of increasing the weight of the missile, of rendering it very expensive, of increasing its susceptibility to trouble, of possibly producing unintentional interference in the operation of the two types of spoiler plates, of requiring a considerable amount of electric energy, and of producing a high air or water resistance.

Although a more simplified system has also been proposed which only requires four spoiler plates, three of which are remote-controlled by steering impulses, while the fourth is controlled by a gyroscope, such a system has the disadvantage that a missile, the movements of which are thus controlled and stabilized is always subject to irregularities in its flight path because of the periodic asymmetry or unbalance of the control impulses resulting from such a system.

It is an object of the present invention to provide a steering and stabilizing system for missiles which overcomes the above-mentioned disadvantages of the known systems and may be produced and operated at a lesser expense than the simplified system as last described.

The present invention consists in functionally combining the operating means of each steering element of a missile with an apparatus for steering the missile which may be located, for example, at a point remote from the missile and also with an automatically operated apparatus which is located on the missile itself for stabilizing the movements of the missile during its flight. The invention therefore proposes either to subject all of the steering elements of the missile to the commands given by the steering control apparatus, for example, a remote control apparatus, as well as to the effects of the stabilizing apparatus when the missile is effectively stabilized about its longitudinal axis, or to subject only some of the steering elements, preferably those located within the same plane, to the effects of both apparatus when the missile undergoes small stabilizing oscillating movements about its longitudinal axis.

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According to one preferred embodiment of the invention, the steering impulses or "commands" may be transmitted to the means for operating the spoiler plates by an electric switch system whereby the spoiler plates which are alternately shifted outwardly from the airfoil, fin, or the like at a certain frequency are influenced by the impulses or commands given by the steering control apparatus as well as by those given or produced by the gyroscopic stabilizing apparatus. In order to attain a change in the direction of flight of the missile, the steering impulses may then be given by the remote control apparatus in such a manner that the spoiler plates will remain shifted for a greater length of time toward one side of the airfoil or the like than toward the other, while the gyro stabilizer will permit only those shifting movements of the spoiler plates which produce a rolling moment which has the tendency to return the missile to its normal flight position stabilized about its longitudinal axis. This is attained by interrupting those steering impulses which would increase the deviation from the normal flight position, i.e., from the flight position of the missile which it would assume when stabilized about its longitudinal axis.

The principal advantage of the apparatus according to the invention consists in thereby attaining a steady flight path free of deviations from the intended course and in the fact that this may be achieved at no greater expense than that of the simplified prior apparatus as previously mentioned since it utilizes essentially the same structural elements as said prior apparatus. A further important improvement attained by the invention consists in the fact that the required amount of electric energy supplied by the battery of the missile for operating the new control system is considerably smaller than that required by the known apparatus since no more than two spoiler coils will now be connected at the same time to the battery instead of the four spoiler coils which previously had to be energized. There will also be no noticeable reduction in the acceleration in the lateral and vertical directions which results from a steering command, provided that the degree of efficiency of each spoiler is made as great as that of the gyro-controlled spoiler plate of the mentioned prior apparatus.

These and other objects, features, and advantages of the present invention will become more apparent from the following detailed description, particularly when read with reference to the accompanying drawings of one preferred embodiment of the invention, in which:

FIGURE 1 shows an electric circuit diagram of the control means for operating the steering elements of a missile which is steered and stabilized according to the invention, the gyro stabilizer control arrangement thereof being shown as would appear to an observer located in front of the missile;

FIGURE 2 shows diagrammatically a simplified rear view of a missile which is steered and controlled according to the invention, and the steering elements of which consist of spoiler plates, two of which are slide out so as to produce a right-hand rolling moment during rectilinear flight;

FIGURE 2a shows a view similar to FIGURE 2 of the same missile with two spoiler plates being slid out so as to produce a left-hand rolling moment during rectilinear flight;

FIGURE 3 shows a view similar to FIGURES 2 and 2a of the same missile with the two spoiler plates being slid out so as to produce a right-hand rolling moment as well as a turning moment which is superimposed upon the rolling moment and directed about the lateral axis of the missile for attaining a climbing of the missile;

FIGURE 4 shows a view similar to FIGURE 3 of the same missile with two spoiler plates being slid out so

as to produce a right-hand rolling moment as well as a turning moment which is superimposed upon the rolling moment and directed about the vertical axis for making a right turn;

FIGURE 5 shows diagrammatically a rear view of the missile similar to FIGURES 2, 2a, 3, and 4, and indicates the various axes of the missile and the directions in which the spoiler plates are shifted to produce aerodynamic forces;

FIGURE 6 shows a diagrammatic perspective view of the missile; while

FIGURE 7 shows diagrammatically a simplified illustration of the gyro stabilizer and its associated mechanism and seen by an observer located to the rear of the missile.

Referring to the drawings, in which the arrows shown in FIGURES 2 to 4 indicate the direction in which the missile is moved by the effect of the steering elements, FIGURE 6 illustrates a missile 1 which is provided with four airfoils 41, 42, 43, and 44 extending at right angles to each other. At the rear end of and within each airfoil, a spoiler plate is mounted which is adapted to be shifted in a direction perpendicular to the longitudinal axis of the airfoil and which in its normal position projects equally from both sides of the airfoil, the projecting parts at the two side of airfoils 41, 42, 43, and 44 being indicated in the drawings by the numerals 31 and 32, 33 and 34, 35 and 36, and 37, 38, respectively as shown in FIG. 5. The directions in which the respective spoiler plate must be shifted in order to render the respective part 31 to 38 thereof effective are indicated in FIGURE 5 by numerals which are twenty numbers higher, that is, by numerals 51 to 58, respectively. In order to shift the spoiler plates in one of the directions 51, 52, 53, 54, 55, 56, 57, and 58, electromagnet coils 11 to 18 (FIG. 1), respectively, are provided within the respective airfoils. When energized by an electric current, these coils 11 to 18 act upon the respective spoiler plates 31 to 38 forming the armatures of the electromagnets to alternately shift them in one direction or the other.

As shown in FIGURE 1, relay 5 within missile 1 may be operated by current impulses of a constant frequency which are transmitted thereto preferably by wire lines 5' from a suitable impulse generator or control station 2 which is located at a point remote from missile 1. These impulses are intended for steering the missile about an axis C (FIGURE 5) which, in the embodiment illustrated, is inclined at an angle of 45° relative to the vertical axis A and simultaneously forms the axis of airfoils 41 and 42. As relay 5 is energized by the current pulses sent from the remote control station 2, it alternately operates switches 7 and 8 to connect either the spoiler coils 11 and 14 or 12 and 13 to one terminal of a battery 26 provided in missile 1. The other terminal of battery 26 is connected through a contact breaker generally designated by reference numeral 25, which forms part of the stabilizing control of the missile in accordance with the present invention and which will be subsequently described, with the other ends of spoiler coils 11 to 14. Consequently, if this were not partly prevented by contact breaker 25, spoiler plates 31, 32 and 33, 34 of airfoils 41 and 42, respectively, would be alternately shifted in one direction or the other. A second relay 6 which is likewise mounted in missile 1 may also receive current pulses of the same frequency as those sent to relay 5 from the remote control station 2, for example, through wire lines 6' for steering the missile about an axis C' which forms the axis of airfoils 43 and 44 and extends perpendicularly to the axis C. Relay 6 will then be energized to operate switches 9 and 10 to connect either spoiler coils 15 and 18 or 16 and 17 to one terminal of battery 26, the other terminal of which is likewise connected through contact breaker 25 to the other ends of these coils so that spoiler plates 35, 36 and 37, 38 of airfoils 43 and 44, respectively, would be alternately shifted out-

wardly in one direction or the other except for the interruption of the steering pulses by contact breaker 25 to be described more fully hereinafter. This alternating movement of spoiler plates 31, 32 and 33, 34 and of spoiler plates 35, 36 and 37, 38 occurs at the same repetition rate at which relays 5 and 6 are operated provided the sliding contact 75 of contact breaker 25 is in the center position thereof corresponding to the desired stabilized flight condition of the missile in which it simultaneously establishes a current from the positive terminal of battery 26 with lines 21 and 22 by effectively bridging contact banks 23 and 24 as will appear more fully hereinafter. This is attained by transmitting the impulse sequences through wire lines 5' and 6' to relays 5 and 6 at the same frequency. The phase displacement and the length of the individual pulses, for example, of conventional square pulses may, however, be adjusted entirely independently of each other for the different lines 5' and 6' in any conventional known manner.

For a rectilinear flight of missile 1, the steering impulses are given by the remote control station 2 so that switches 7 to 10 will be operated regularly at equal intervals for instance, by transmitting symmetrical square pulses varying in a conventional manner in amplitude between two predetermined values at regular intervals or periods of time so that each amplitude level occurs for substantially the same length of time as the other amplitude level. If a turning movement about the lateral axis B is to be produced for attaining a change of movement of the missile in the upward direction, the pulses transmitted to relay 5 through lines 5' will be changed by any conventional means so that, at the same frequency and amplitude thereof, switches 7 and 8 will connect spoiler coils 11 and 14 with battery 26 for a greater length of time than coils 12 and 13. Consequently, spoiler plates 31, 32 and 33, 34 will remain shifted in the directions 51 and 54, respectively, for a longer time than in the directions 52 and 53. This can be accomplished in any known manner, for instance, by lengthening one pulse while shortening the next pulse so that one amplitude level of the square pulses will become longer while the opposite amplitude level of the pulses will become shorter, resulting in asymmetric pulses which are modulated with respect to the pulse length thereof. Similarly, by sending suitable modified pulses to relay 6, spoiler plates 35, 36 and 37, 38 will remain shifted in the directions 56 and 57, respectively, for a longer time than in the directions 55 and 58. With each change, the spoiler plate parts seeking to steer the missile in the upward direction will therefore remain shifted outwardly for a longer period of time than the spoiler plates seeking to steer the missile in the downward direction. The difference in the length of time of the two shifting periods results in a change of movement of the missile, and such difference may become so great that the spoiler plates will effectively remain shifted in one direction to effect maximum changes in flight direction. The steering function in any other flight direction proceeds in an analogous manner.

The contact breaker 25 forms an element of a stabilizing apparatus consisting of a gyroscope 71 (FIG. 7) which is mounted within a frame 73 so as to be rotatable about an axis 72. Frame 73, in turn, is pivotable about an axis 74 which extends perpendicularly to axis 72 and parallel to the longitudinal axis D of the missile. Frame 73 carries a sliding contact 75 which is adapted to slide along contact banks 23 and 24 which are connected to spoiler coils 11, 13, 15, 17 and 12, 14, 16, 18, respectively, by conductors 21 and 22, respectively. Sliding contact 75 and contact banks 23 and 24 therefore form the different electrodes of the contact breaker 25.

If the missile carries out a rolling movement about its longitudinal axis D toward the left from its normal position, i.e., a counterclockwise rolling movement as seen in FIGURES 2 to 4 and 7 and a clockwise movement as seen in FIGURE 1, sliding contact 75 will

move toward contact bank 24, as shown in the direction of flight in FIGURE 7, so that line 21 will be dead and spoiler coils 11, 13, 15, and 17 will be deenergized. Spoiler coils 12, 14 and 16, 18 will then receive alternating current impulses through line 22 in accordance with the oscillation of relays 5 and 6 so that the spoiler plates will slide alternately in the directions 52 and 54 or 56 and 58, respectively. FIGURE 2 illustrates in full lines the positions of the spoiler plates which correspond to the positions of relays 5 and 6 as shown in FIGURE 1, and it also illustrates in dashed lines those positions of the spoiler plates which correspond to the respective positions of relays 5 and 6 opposite to those shown in FIGURE 1. The total length of time during which the relays remain in each position is equal among each other and equal to the period of oscillation of the relay frequency if no command signal is transmitted from the remote control station to change the course of flight of the missile. All four spoiler plates produce the same restoring or corrective rolling moment, i.e., clockwise rolling movement as seen in FIGURE 2 which seeks to restore the missile to its normal position in which its lateral axis B extends horizontally and in which contact arm 75 would establish an electrical connection with both contact banks 23 and 24. Due to its kinetic rotary energy, the missile will, however, move beyond its normal or zero position so that the sliding contact 75 will slide upon the contact bank 23. Through line 21, the spoiler coils working in the opposite direction will thus be connected to battery 26 so that the spoiler plates will be shifted outwardly in the direction as indicated in FIGURE 2a and impart to the missile a rolling movement in the opposite direction to FIGURE 2, i.e., in the clockwise direction as seen in FIGURES 2a and 7. The missile will thus carry out continuously oscillating rolling movements of a few degrees in either direction from its normal position under the control of the stabilizing apparatus 25 which compensate each other and do not have any influence upon the direction of flight. This oscillatory rolling movement may be reduced by inserting a precession element of a type known as such between sliding contact 75 and the contact bars 23 and 24. This will give the missile a rolling moment in the opposite direction even before sliding contact 75 passes beyond the normal position of the missile, so that the deflection in the other direction will be at least partly suppressed.

The stabilization of the rolling moment is superimposed upon the steering control in such a manner that only the spoiler coils which are connected by contact breaker 25 will also be connected by relays 5 and 6 to battery 26 and thus be controlled by the steering pulses sent by the remote control station 2 through lines 5' and 6'. The spoiler plates will therefore carry out only those of the oscillatory movements in one direction as above described which are permitted by contact breaker 25. During the period in which the regular shifting movements of the spoiler plates would produce a rolling moment in the opposite direction, the respective spoiler plates will remain in the zero position. Thus, there will always be two spoiler plates in the zero position, and two other spoiler plates shifted in one direction. Both pairs of spoiler plates are shifted alternately in equal rolling directions, and the steering function is effected by the different length of time during which they remain shifted outwardly. If a steering command is given to cause a climbing of the missile and at the same time the stabilizing apparatus is set to produce a corrective rolling movement toward the right, as illustrated in FIGURE 3, spoiler plates 33, 34, and 35, 36 will be shifted by suitably modifying the length of the control pulses in the directions 54 and 56 for a longer period than spoiler plates 31, 32 and 37, 38, as indicated in dotted lines, which are shifted in the directions 52 and 58, the dotted line for spoilers 32 and 38 indicating that they will remain for a shorter period of time in the positions illustrated in FIGURE 3 than the full-line spoilers 34 and 36. During the follow-

ing corrective rolling movement toward the left, not shown in FIGURE 3, while the steering command for climbing is being given, spoiler plates 31, 32 and 37, 38 remain shifted in the directions 51 and 57 for a longer period than spoiler plates 35, 36 and 33, 34 remain shifted in the directions 55 and 53 (FIGURES 2 and 2a). With a command for a right turn while rolling toward the right, as shown in FIGURE 4, spoiler plates 33, 34 and 37, 38 remain shifted in the directions 54 and 58 for a longer period than spoiler plates 35, 36 and 31, 32 which are shifted in the directions 56 and 52, as shown in dotted lines in FIGURE 4. All other steering movements will be produced in the same manner as described above by alternating shifting movements of two pairs of spoilers for different lengths of time.

For maximum changes in direction, one pair of spoiler plates will remain shifted outwardly, while the other pair is not shifted. For maximum climbing or right turns, the spoiler plates indicated in dotted lines in FIGURE 3 or 4, respectively, will therefore not be shifted at all during the rolling movement toward the right, while the spoilers shown in full lines will remain in the shifted position.

As indicated in the beginning, the present invention is not limited to missiles or even to aircraft generally, and the same principles described herein may also be applied to floating bodies, for example, torpedoes, or to other kinds of watercraft. The invention is also not limited to the operation of the spoiler plates by an electric control system, but the control forces may also be transmitted thereto by any other suitable means which may be of a hydraulic, pneumatic or mechanical type. In place of spoiler plates, it is also possible to apply other kinds of steering elements, such as rudders, fins, or the like, and the type of movement of such elements need not be a sliding movement, but may also be a pivotal movement.

Although my invention has been illustrated and described with reference to the preferred embodiment thereof, I wish to have it understood that it is in no way limited to the details of such embodiment, but is capable of numerous modifications within the scope of the appended claims.

Having thus fully disclosed my invention, what I claim is:

1. A control mechanism for steering and stabilizing the movements of a body traveling in a fluid medium, said body being generally symmetrical about its longitudinal axis and being steerable in any direction relative to its path of movement and having limited rotation in opposite directions relative to its longitudinal axis which generally coincides with its path of movement to stabilize the body during its movements, comprising a plurality of steering elements on said body, means for operating said steering elements, said operating means including remote control means separate from said body and means carried by said body and so constructed and arranged as to communicate with said remote control means for controlling each of said steering elements on said body for steering the same, automatically acting stabilizing means on said body, and connecting means for operatively and selectively connecting and disconnecting each of said steering elements with said connecting means being so constructed and arranged that each of said steering elements is operated only by superimposed control functions of said operating means and said stabilizing means, whereby the operated position of each steering element is dependent upon the condition of both said stabilizing means and said operating means.

2. A control mechanism as defined in claim 1, wherein said body is provided with a plurality of finlike structures generally symmetrically disposed about the longitudinal axis of the body and wherein said steering elements comprise only one steering element on each of said fin-like structures.

3. A control mechanism as defined in claim 1, wherein said remote control means comprise at least one generator for producing impulses of a uniform frequency and means

for varying the length of said impulses, a plurality of finlike structures generally symmetrically disposed about the longitudinal axis of said body, said steering elements comprising only one steering element on each of said finlike structures, said operating means further comprising actuating means on said body for each of said steering elements, at least one relay on said body for operating said actuating means, and wire means operatively connecting said relay to said generator.

4. A control mechanism as defined in claim 3, wherein said actuating means comprise switch means connected to and adapted to be operated by said relay, an electromagnetic coil for operating each of said steering elements, and a source of electric current having one terminal connected to said switch means, said electromagnetic coils each having one end adapted to be connected to said switch means and through said switch means to said terminal, a contact breaker connected to said source of current and also connected to and controlled by said stabilizing means, each of said electromagnetic coils having another end adapted to be connected to said contact breaker, said contact breaker being adapted to selectively connect said other terminal to said other ends of some of said electromagnetic coils and to disconnect said other terminal from the other coils in accordance with the movements of said stabilizing means.

5. A control mechanism as defined in claim 4, wherein said stabilizing means comprise a gyroscope, said contact breaker comprising a contact bank having two separate contacts thereon, each connected to said other ends of one of two sets of said electromagnet coils, and a sliding contact adapted to slide along said contact bank and mechanically connected to said gyroscope to be shifted thereby.

6. A control mechanism as defined in claim 5, wherein said contacts of said contact bank are disposed in such a relation to said sliding contact that, when the lateral axis of said body is inclined out of the horizontal plane by a rolling movement of said body, said gyroscope moves said sliding contact so as to engage only one of said contacts of said contact bank which is connected to those electromagnet coils which, when energized, actuate said steering elements to produce a movement of said body about its longitudinal axis which has a tendency to counteract said rolling movement and said inclination of said lateral axis.

7. A control mechanism as defined in claim 6, wherein each of said switch means operated by said relay has two switch positions adapted to be alternately connected to those of said electromagnetic coils which are adapted to cause the counteracting rolling movement.

8. A control mechanism as defined in claim 3, wherein said operating means comprise two relays on said body, said steering elements including the actuating means thereof being divided into two sets, each of said sets being adapted to be actuated by one of said relays for producing a turning movement about an axis of said body, the two axes extending at right angles to each other.

9. A control mechanism as defined in claim 2, wherein said steering elements consist of spoiler plates.

10. A control mechanism as defined in claim 9, wherein each of said spoiler plates is adapted to be shifted in a direction at right angles to the central plane of the respective fin-like structure and toward both sides thereof.

11. A control mechanism for steering and stabilizing the movements of a body traveling in a fluid medium, said body being generally symmetrical about its longitudinal axis and being steerable in any direction relative to its path of movement and having limited oscillatory rotation about its longitudinal axis for stabilization, comprising a plurality of steering elements on said body, means for operating said steering elements, steering control means carried by said body and responsive to a steering signal for controlling the operation of each of said steering elements for steering said body, automatic stabilizing means on said body for controlling the operation of said elements to maintain stabilization of said body with respect to its longitudinal axis, and control means for operatively and selectively connecting and disconnecting the operating means for each of said steering elements for control by said stabilizing means, said last-mentioned control means being operatively connected and responsive to said steering control means and so constructed and arranged to actuate each said steering element only to positions in which it simultaneously tends to steer said body in accordance with said steering signal and effect rolling movement to return the body to a predetermined stabilized position with respect to its longitudinal axis.

12. A control mechanism for steering and stabilizing the movements of a body traveling in a fluid medium, said body being generally symmetrical about its longitudinal axis and being steerable in any direction relative to its path of movement, said body being essentially non-rotatable about its longitudinal axis during steering movements, but having limited rolling movement in opposite directions about its longitudinal axis for stabilizing the body relative to its path of movement, comprising a plurality of movable steering elements on said body for reacting with said fluid medium to control movements of said body, motive means for moving said steering elements relative to said body, means on said body for receiving steering control signals from a control station remote from said body, automatically acting stabilizing means on said body for providing a stabilizing control effect dependent upon the angular position of said body about its longitudinal axis with respect to a desired stabilized position, and means operatively connected with said motive means as well as with said receiving means and said stabilizing means to effect movement of each said steering element only in dependence upon the condition of both said receiving means and said stabilizing means, said last-mentioned means providing movement of said steering elements to only respective positions thereof which tend to produce a rolling moment tending to roll the body to maintain a desired stabilized position.

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