Oct. 27, 1936. W. B. KLEMPERER ET AL 2,058,803

CONTROL FOR VESSELS

Filed Oct. 19, 1934 2 Sheets-Sheet 1

Fig. 1.

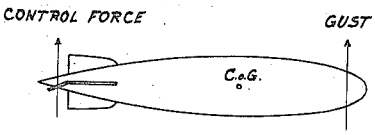


Fig. 2.

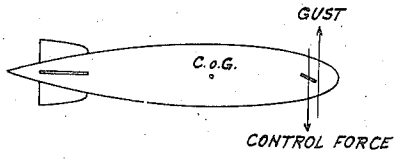


Fig. 3.

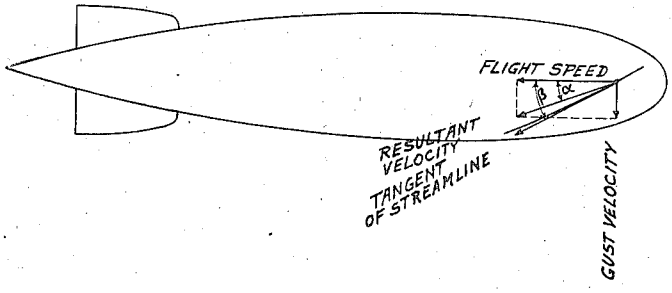
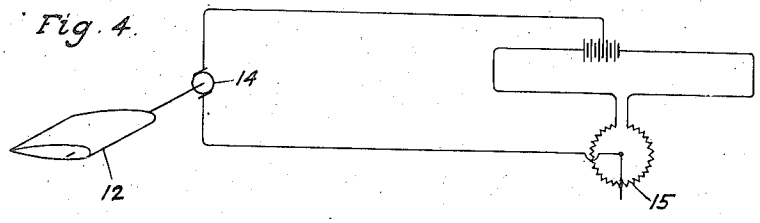


Fig. 4.



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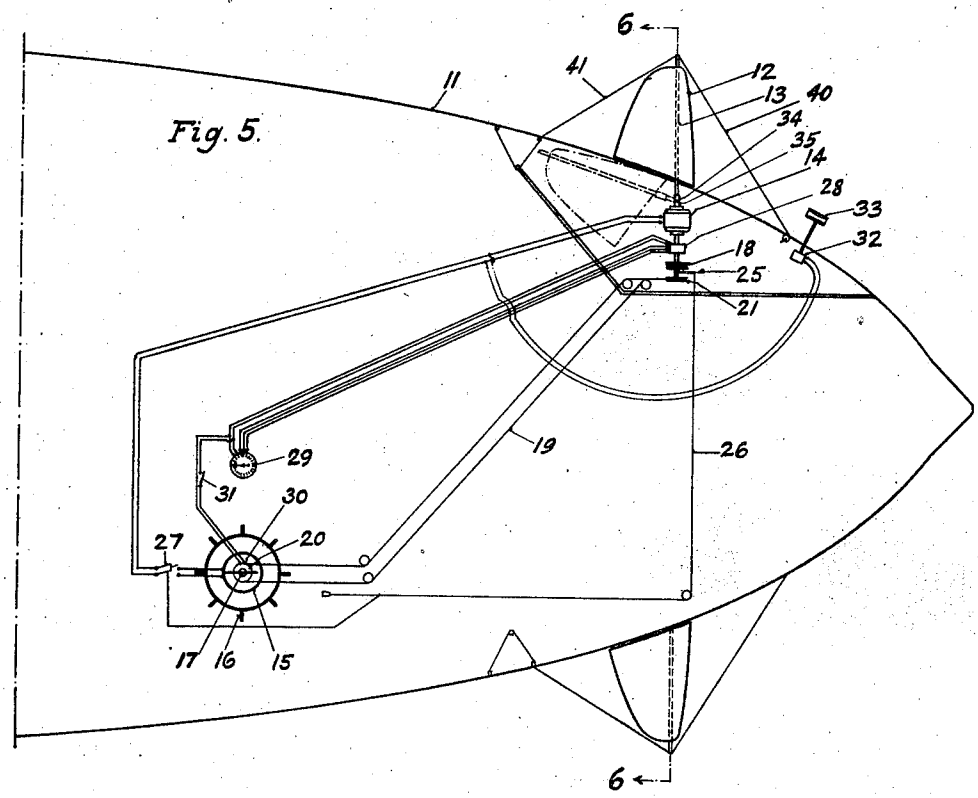
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CONTROL FOR VESSELS

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Fig. 5.



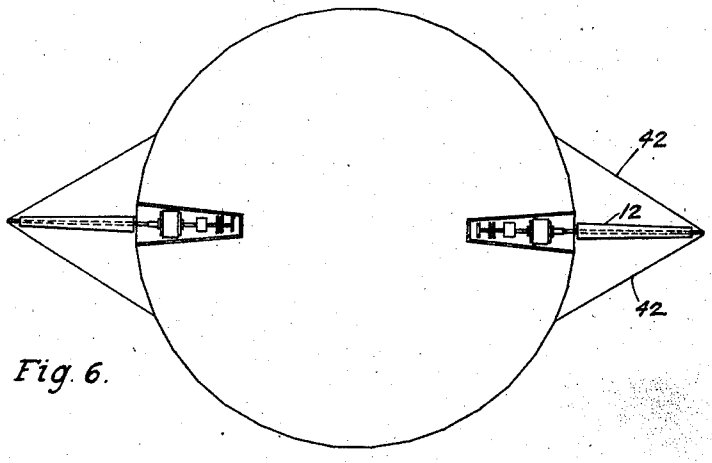


Fig. 6.

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CONTROL FOR VESSELS

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23 Claims. (Cl. 244—29)

This invention relates to the arrangement and operation of vessels, such as airships, and more particularly is concerned with bow controls for said airships.

Bow elevators on airships have been tried on certain early airships but were later abandoned when it was found that tail fins were indispensable and tail elevators attached to them were so effective as to be sufficient under normal operating conditions.

More recently, however, conditions have been encountered in which the availability of an additional steering device on the ship's bow would appear desirable. Such instances are the checking of a dive from low altitude, the zooming up from a take-off field or the hurdling of a ground obstacle. In these maneuverings, when performed with tail elevators alone, the tail of the ship is depressed and sweeps through a lower arc than the path of the center of buoyancy does because the action of the tail elevator is an indirect one. It actually elicits a down force on the tail in order to pitch the ship up so that its own propellers can drive it upwards. Bow elevators, on the other hand, act directly by creating an up force in front of the center of buoyancy in order to pitch the ship upwards. Therefore the danger of the tail fin striking the ground is definitely lessened when the maneuver is assisted or initiated by bow elevators. In hurdling an obstacle the maneuver of climbing the bow over it with up bow elevators and then lifting the tail over it with the tail elevators is especially useful.

Another potential advantage of bow elevators is derived when flying through gusty weather while trying to steer the ship steadily and to check the disturbances produced by the gusts. Whenever the ship runs into a zone of different wind direction or into a vertical current its bow is attacked by the disturbances first. Therefore the ship tends to veer to leewards or in the direction yielding to the currents. Any attempt to combat this veerage, and to keep the ship on her course or on an even keel with tail control surfaces alone evokes a bending moment, and enhances the drift or change of altitude. This is because the disturbance (wind gust) attacks in front of the ship's center of gravity while the control force acts in the rear of the center of gravity (see Fig. 1).

On the other hand, if the gust were to be counteracted by a bow elevator (see Fig. 2), its force would be intercepted right at or near its seat of attack and only the difference, if any, would be left to throw any bending moment into the ship as a beam. Thus, bow control surfaces when operated to combat gusts may save the ship from the punishment of large and frequent bending moments and also smooth out its path and minimize its deviations of course and altitude in gusts.

Since bow control surfaces can be arranged independent of any fixed fins, they lend themselves well to good aerodynamical balance in such fashion that it takes only very little effort to incline them to any angle of incidence within their effective range of angles of attack. For instance when they are arranged to be rotatable about an axis only slightly forward of the forward quarter of their depth from leading edge, the torque required to hold them at a particular angle of attack can be very small.

Now besides these advantages, bow control surfaces of conventional design, such as would consist of one or several surfaces mounted rotatably with reference to the ship's hull and attached through horns or segments, cables or wires to a control wheel operated by a helmsman, would possess four serious disadvantages. Our invention aims at obviating these disadvantages and thereby rendering bow control surfaces amenable to practical usefulness.

These disadvantages and their remedy by our invention will now be considered.

For one thing bow control surfaces, when held in neutral and not alertly operated in gusts would act as fins in the wrong place, namely forward of the center of gravity. In this condition they would actually reduce the dynamic stability of the craft and enhance both the stresses and deviations incurred. Secondly under the very same condition, even the most alert incidence control would suffer from an undesirable lag inasmuch as the bow surface would not begin to furnish any restoring force until they have reached an incidence greater than the angle of the relative wind in their place. This relative wind makes an angle α with the ship's axis, whose tangent one would expect to be the ratio of the transverse component velocity of the gust to the flight speed. Wind tunnel tests have recently revealed, however, that the actual angle of the streamlines on the bow of an airship under oblique attack are even steeper (β) because the flow tends to escape around the hull of the ship, (see Fig. 3), thus enhancing the difficulty just explained.

These two disadvantages are at once overcome by the following new expedient: The bow control surfaces are not connected directly to a control

wheel controlling their angular incidence but they are hinged to float or trail freely in the wind that hits them. To insure free trailing or vaning, their axis is disposed well within the forward quarter of the surface from their leading edges. Thus vaning they do not act as fixed fins, nor would they detract from the ship's dynamic stability, and in gusts they are always ready to offer immediate response to any control command that is superimposed to their incidental position. Deliberate control according to our invention is effected by suitable means such as a torquemotor. A torquemotor is a device which imposes a torque of controlled magnitude and direction upon a shaft independent of the instantaneous angular position of this shaft and essentially independent of its rotary velocity if it happens to be rotating slowly. Electric torquemotors are commercially available. This invention while fully explained by reference to an electric torquemotor should not be construed to be limited to electric torquemotors, since any hydraulic, pneumatic, aerodynamic or mechanical torquemotor similar in action, provided it does not contain any self-locking gearing, may give the same action, as those skilled in the art will be well aware.

Deliberate control from a helmsman's wheel is now, according to the present invention, obtained by means regulating the input of the torquemotor in accord with the position of the helmsman's wheel. These means may take the form of a potentiometer rheostat control (see Fig. 4). Here any rotation of the wheel away from neutral will feed more voltage, in one direction or another, to the torquemotor. The latter will therefore turn the control surface to the angle of attack where the resistive moment of the air forces tending to trail the surfaces is equal or balanced by the torque imparted independent of the instantaneous direction of the varying neutral or stream plane.

It will be noted that torque control has the desirable feature of producing larger control angles for any given wheel position, at low speeds (where air forces are smaller) than at high speed. This characteristic at once provides ample control at low speed when it is most needed and safeguards the ship against brusque maneuvers at high speed where they are not needed but only cause punishment.

Another method of electrical torquemotor control lends itself well if alternating current power is available. Here the means for input control may take the form of a device shifting the phase of the current, for instance between the stator and the rotor of the torquemotor.

It will be noted that with this novel method of steering through torque impulses rather than compulsory incidence control, the helmsman with equipment such as described so far would not know the position or incidence which the bow surfaces assume at any time, nor how they respond to his commands. In order to supply him with this knowledge the invention contemplates provision for a remote indicating incidence indicator which may take the form of an electrically operated position transmitter. A preferred form of this instrument consists of a pair of selsyns, one coupled to the control surface, the other in the control room and carrying a pointer moving in front of a graduated dial.

The torquemotor drive of bow or other surfaces lends itself well to automatic control. If it is for instance desired to arrange the system so as to be automatically responsive to impulses obtained from some apparatus or instrument which is itself sensitive to some physical characteristic of the ship's motion as described in Klemperer Patent No. 1,763,590. Thus an altimeter, an inclinometer or a gust detector could be operatively connected to an input controller similar to that attached to the hand wheel as hereafter described in detail. The two control commands can be arranged to be used either independently or together.

Occasions may arise, for instance during landing or take-off, when the helmsman wishes to obtain direct control of the incidence angle of the bow control surfaces in conventional fashion. To enable him to do this at will, the present invention contemplates provision of a clutch or coupling permitting a direct control line to be brought into operating relation with the control surface. This control line would be operated either by a separate hand wheel or by the same hand wheel as was the torquemotor. The mechanism engaging or disengaging this clutch can be hand operated and may be combined with a switch cutting the electric or torque control in or out simultaneously, although this is not necessary as the direct angle control would overrule the torque impulse.

Whether the torquemotor is arranged between the clutch and the surface as shown or the clutch between the motor and the surface is immaterial for the principle of the invention.

Occasions may arise, for instance in ground handling, where it might be undesirable to have the free floating bow control surfaces swing around unchecked. To guard against this they can be equipped with a locking device locking them temporarily in neutral.

The third difficulty to mention in connection with bow elevators is their weight balance. Since the axis has to be well forward the surfaces are likely to become tail heavy. Although it is naturally possible to balance them by a counter weight or to some degree by a long spring suitably attached, the present invention also contemplates compensating the overweight by a constant torque. This constant torque can be supplied either by a spring of automatically controlled constant force or, preferably, by suitably adjusting a definite torque to be supplied by the torquemotor itself when the controls are in neutral and always present additive or subtractive to the control torque.

Inasmuch as the balancing torque required will vary when the ship is inclined at different attitudes to the horizon, a correction of this balancing torque proportional to the cosine of the attitude angle and controlled automatically by an inclinometer is preferably provided.

The fourth disadvantage of bow controls not yet mentioned is their additional parasite drag. This drag is of course also reduced by the floating arrangement inasmuch as the surfaces when not required in action would always trail in the attitude of least resistance. However, occasions of relatively long stretches of steady voyages in smooth air may occur where the bow elevators would not be needed for an extended period. The present invention contemplates retracting them during these periods inside the hull. Accordingly they would be mounted where the design of the hull structure offers opportunities for a suitable recess into which the control surfaces would be wholly or partly retracted. Deep main frames for instance of triangular construction or longitudinal gangways are envisaged to be so built as to

house the retracted parts without detrimental encroachment of the gas space inside the hull.

While some of the advantages of bow control surfaces are most convincingly demonstrable for altitude control, the present invention is not meant to be limited to the control in the plane of pitching, but also to cover rudders for directional or course control in the plane of yawing, or any arrangement for other directional control in space as well. It is also pointed out that although manual control literally understood would mean hand operated, operation through foot pedals or any other muscular operation should be considered within the scope of this invention.

The foregoing and other objects of the invention are achieved in the invention hereinafter specifically described and illustrated in the accompanying drawings.

Figs. 1, 2 and 3 are diagrams explaining the effect of a vertical gust on a ship in flight and its control by stern and bow elevators, respectively.

Fig. 4 is a diagrammatic sketch of the electric control of the bow elevator.

Fig. 5 is the diagrammatic view of the bow of an airship, showing the elevator arrangement and its operating mechanism.

Fig. 6 is a cross-sectional view taken at lines 6—6 in Fig. 1.

Referring to Fig. 5, the bow of the airship hull 11 carries the elevator surfaces 12 mounted on the shaft 13, which is in releasable engagement with the electrical torquemotor 14. This torquemotor is controlled by the electrical input controller 15 mounted on the handwheel 16 or the handwheel shaft 17. By turning the handwheel the electric current for the torquemotor flowing through the input controller is being regulated to suit the power required for turning the elevator surface.

At the end of the elevator shaft 13 is provided a disengageable clutch 18, which carries a segment or sprocket 21. A control line 19 leading over a sprocket 20 mounted on the handwheel shaft, operatively engages the segment or sprocket 21 to thereby mechanically connect and control the turning of the elevator shaft. The lever 25, disengaging the clutch 18, is operated by means of a control line 26 from the helmsman's stand located in the control car. The control line 26 is connected with the electrical switch 27 in electric line leading to the torque motor in such a way that the electric current feeding the torque motor is cut off, as soon as the clutch on the elevator shaft is engaged.

In order to know at all times the angle of incidence of the elevator surface, a selsyn transmitter 28 of standard design may be mounted on the elevator shaft and is electrically connected with a selsyn position indicator 29 provided with a dial and hand and mounted in the control room. The current for the selsyn indicator system passes through electric contacting rings 30 secured to the handwheel shaft, or the electricity may be supplied directly through a switch 31 from an electric power source.

For operating the elevator surface entirely automatically an electric controlling apparatus 32 is employed, which is sensitized by a Venturi tube 33 as described and claimed in Klemperer Patent 1,763,590, which tube is positioned in the air stream of the airship preferably at the top thereof. In the drawings this is shown at 90° from its actual position as disclosed in the construction illustrated in said Patent No. 1,763,590. That is the venturi should be positioned 90° from the surface which it controls. In this case the handwheel is not operated and the electric torquemotor 14 is directly connected with the electric controlling apparatus 32. In case the bow elevator is not desired to be operated its position is fixed by engaging the clutch and locking the handwheel against turning.

When, during flight, the bow elevator surfaces are not needed, the air resistance, due to their projecting from the ship's hull, can be partly or entirely eliminated by swinging the surfaces inside the airship hull. One manner of accomplishing the retraction of the control surfaces is by making the elevator surface shaft in two sections which are advantageously connected by a hinge 34. The hinge, while the elevator is in operation, is locked by a sleeve 35. When the elevator is to be retracted into the airship hull, the hinge is unlocked either directly or by a remote control, operated from the elevator control stand. In retracting the elevators the front braces 40 may be tensioned by winches inside the hull, which are then slowly released under tension while the rear braces 41 are becoming slack and are stowed away inside the ship, whereas the upper and lower braces 42 are so mounted on the structure that they do not change their length when the elevators are swung inwardly. Therefore, the elevators are held in proper position vertically to insure safe retraction of the surfaces.

From the foregoing description it is believed that the operation and structure of this novel airship control will be understood. It will be appreciated, therefore, that a construction has been provided which, due to the floating arrangement of the control surfaces, eliminates the disadvantages of the fixed surfaces to a large degree so that their practical application is possible and preferable.

Although we have described and illustrated only certain forms our invention may assume, it will be apparent to those skilled in the art that it is not limited thereto or thereby but is defined in the appended claims.

What we claim is:

1. In an airship, a bow control surface located forwardly of the center of buoyancy of the airship, a shaft located less than a quarter of the mean chord length aft of the leading edge of said surface, about whose axis the surface is freely pivotable under the influence of the relative wind flowing past said surface, and a torquemotor coupled to said surface.

2. In an airship, a bow control surface located forwardly of the center of buoyancy of the airship, a shaft located less than a quarter of the mean chord length aft of the leading edge of said surface, about whose axis the surface is freely pivotable under the influence of the relative wind flowing past said surface, a torquemotor coupled to said surface and means to manually control and reverse the input of said torquemotor.

3. In an airship, a bow control surface located forwardly of the center of buoyancy of the airship, a shaft located less than a quarter of the mean chord length aft of the leading edge of said surface, about whose axis the surface is freely pivotable under the influence of the relative wind flowing past said surface, a torquemotor coupled to said surface and means to manually control and reverse the voltage of said torquemotor.

4. In an airship, a bow control surface located forwardly of the center of buoyancy of the airship, a shaft located less than a quarter of the mean chord length aft of the leading edge of said

surface, about whose axis the surface is freely pivotable under the influence of the relative wind flowing past said surface, a torquemotor coupled to said surface and means to manually control and reverse the input phase of said torquemotor.

5. In an airship, a bow control surface located forwardly of the center of buoyancy of the airship, a shaft located less than a quarter of the mean chord length aft of the leading edge of said surface, about whose axis the surface is freely pivotable under the influence of the relative wind flowing past said surface means to indicate the angular position of said bow control surface, and a torquemotor for controlling the angle of attack of said surface if and when desired.

6. In a vessel, a control surface located forwardly of the center of buoyancy of the vessel, a shaft located within the forward quarter of said surface, about whose axis the surface is free to pivot under the influence of the relative fluid flowing past said surface, a torquemotor coupled to said surface, means to manually control and reverse said torquemotor and additional means for direct manual control of the incidence angle of said control surface and a clutch to engage and disengage, respectively, either the manual incidence control or the torquemotor control at will.

7. In an airship, a bow control surface located forwardly of the center of buoyancy of the airship, a shaft located less than a quarter of the mean chord length aft of the leading edge of said surface, about whose axis the surface is freely pivotable under the influence of the relative wind flowing past said surface, a torquemotor coupled to said surface and a servo device actuated automatically by an instrument sensitive to some flight parameter calling for a definite control response.

8. A vehicle including a body adapted for movement through fluid, a control surface pivotally mounted on the body and adapted for normal free movement on its pivot and manually controlled means for applying torque to said surface regardless of its angular position at the time it is desired to apply the torque, automatic means for controlling the torque applying means when desired, means for manually applying torque to the surface when desired, and said vehicle having a recess into which the surface can be retracted.

9. An airship including a body adapted for movement through fluid, a control surface pivotally mounted on the body and adapted for normal free movement on its pivot and means normally unconnected with said surface for applying torque to said surface regardless of its angular position at the time it is desired to apply the torque.

10. A vehicle including a body adapted for movement through fluid, a control surface pivotally mounted on the body and adapted for normal free movement on its pivot and means normally unconnected with said surface for applying controlled torque to said surface regardless of its angular position at the time it is desired to apply the torque, and said vehicle having a recess into which the surface can be retracted after the latter has been lined up by said controlled torque in a position to enter said recess.

11. A vehicle including a body adapted for movement through fluid, a control surface freely pivoted on the body, means for selectively controlling said surface but normally unconnected therewith said vehicle having a recess into which the surface can be retracted, and means for retracting said surface into said recess when said control means is connected and is operated to move said surface to a position where it may enter said recess.

12. A vehicle including a body adapted for movement through fluid, a control surface pivotally mounted on the body and adapted for normal free movement on its pivot and manually controlled means for applying torque to said surface regardless of its angular position at the time it is desired to apply the torque, automatic means for controlling the torque applying means when desired, means for manually applying torque to the surface when desired.

13. In an airship, the combination with the body of the airship, of at least two control surfaces pivoted freely and independently on opposite sides of the body, whereby they are individually free to assume positions determined by the air stream flowing thereby, and means selectively connectable to said surfaces for controlling the angle of attack of each surface if and when desired, comprising means for applying a free torque to said surfaces.

14. In an airship, the combination with the body of the airship, of at least two control surfaces pivoted freely and independently on opposite sides of the body, whereby they are individually free to assume positions determined by the air stream flowing thereby, and means selectively connectable to said surfaces, for controlling the angle of attack of each surface if and when desired, comprising a manually controlled torquemotor.

15. In an airship, the combination with the body of the airship, of at least two control surfaces pivoted freely and independently on opposite sides of the body, whereby they are individually free to assume positions determined by the air stream flowing thereby, means selectively connectable to said surfaces, for controlling the angle of attack of each surface if and when desired, comprising a means for rotating said surfaces, and an air stream controlled device on said airship for controlling said last-mentioned means.

16. In an airship the combination with the body of the airship, of at least two control surfaces pivoted freely and independently on opposite sides of the body, whereby they are individually free to assume positions determined by the air stream flowing thereby, means selectively connectable to said surfaces, for controlling the angle of attack of each surface if and when desired, comprising a surface rotating means, and clutch mechanism for selectively connecting each of said surfaces to said surface rotating means whereby the latter can be operated to rotate said surfaces.

17. In an airship, a pivoted bow control surface located forwardly of the center of the buoyancy of the airship on one side thereof, a second similar bow control surface located on the opposite side of the bow, said surfaces being mounted for free pivotal movement independently of each other and any control mechanism therefor, and means for imposing a free torque on both of said surfaces to resist their pivotal movements, said surfaces being free to pivot independently of each other against the free torque applied to said surfaces.

18. In an airship, a bow control surface located forwardly of the center of buoyancy of the airship, a shaft located less than a quarter of the mean chord length aft of the leading edge of said surface about whose axis the surface freely pivots under the influence of the relative wind flowing past said surface, and manually controlled

means for applying torque to said surface regardless of its angular position and independent of any other control surfaces, and a recess on said airship into which said surfaces can be retracted when not in use.

19. In an airship the combination with an airship body of an elevator surface freely pivoted to the bow of said airship, whereby it may assume a normal inactive position in the airstream flowing thereby so that it offers a minimum of resistance to the forward movement of the airship, means selectively operable for actuating said surface to control the angle of attack thereof and being normally inoperative, and means for selectively connecting said control means to said surface whereby said surface can be pivoted as desired to various angles of attack with reference to the airstream.

20. In an airship, the combination with an airship body of an elevator surface freely pivoted to the bow of said airship, whereby it may assume a normal inactive position in the airstream flowing thereby so that it offers a minimum of resistance to the forward movement of the airship, means selectively operable for actuating said surface to control the angle of attack thereof and being normally inoperative, and means for selectively connecting said control means to said surface whereby said surface can be pivoted as desired to various angles of attack with reference to the airstream, comprising a clutch arranged between said surface and said control means.

21. In an airship, the combination with an airship body of an elevator surface freely pivoted to the bow of said airship, whereby it may assume a normal inactive position in the airstream flowing thereby so that it offers a minimum of resistance to the forward movement of the airship, means selectively operable for actuating said surface to control the angle of attack thereof and being normally inoperative, and means for selectively connecting said control means to said surface whereby said surface can be pivoted as desired to various angles of attack with reference to the airstream, said control means comprising a torquemotor, and means for connecting said torquemotor to said surface comprising a manually controlled means for energizing said torquemotor.

22. In an airship, a freely rotatable control surface arranged in unbalanced position on its pivot and located forwardly close to the balanced end of the ship and means for balancing the unbalanced weight of said surface by exerting a resistance to the movement of the surface due to its unbalanced weight sufficient to compensate for the unbalanced weight thereof, comprising a torquemotor.

23. A device as set forth in claim 22 in which the torquemotor is capable of increasing or decreasing the angle of said surface from the zero position where said torquemotor normally balances the unbalanced weight of said surface.

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