June 2, 1925.

1,540,104

J. F. COOK, JR

AIRPLANE

Filed Dec. 18, 1922

5 Sheets-Sheet 1

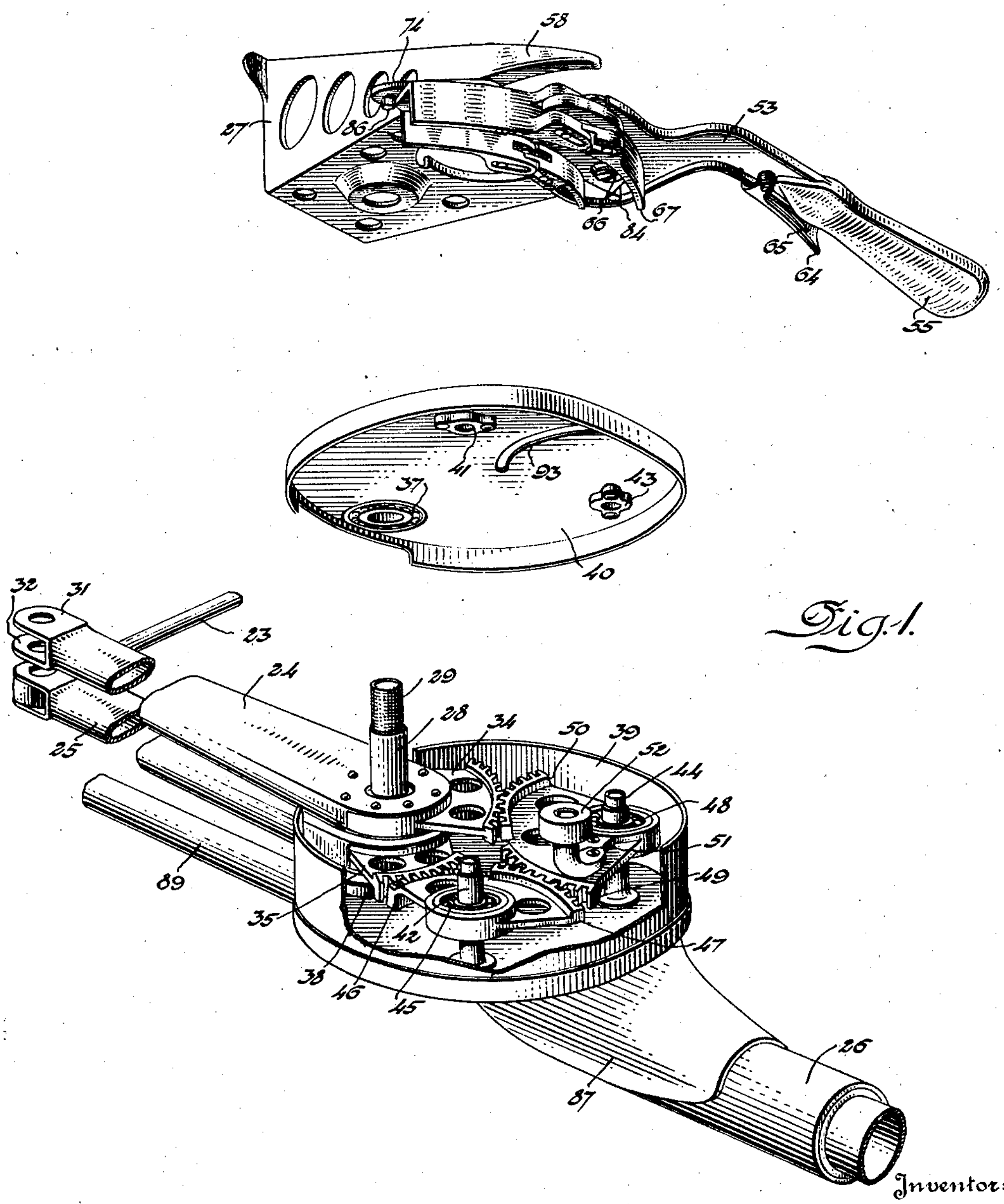

Fig. 1.

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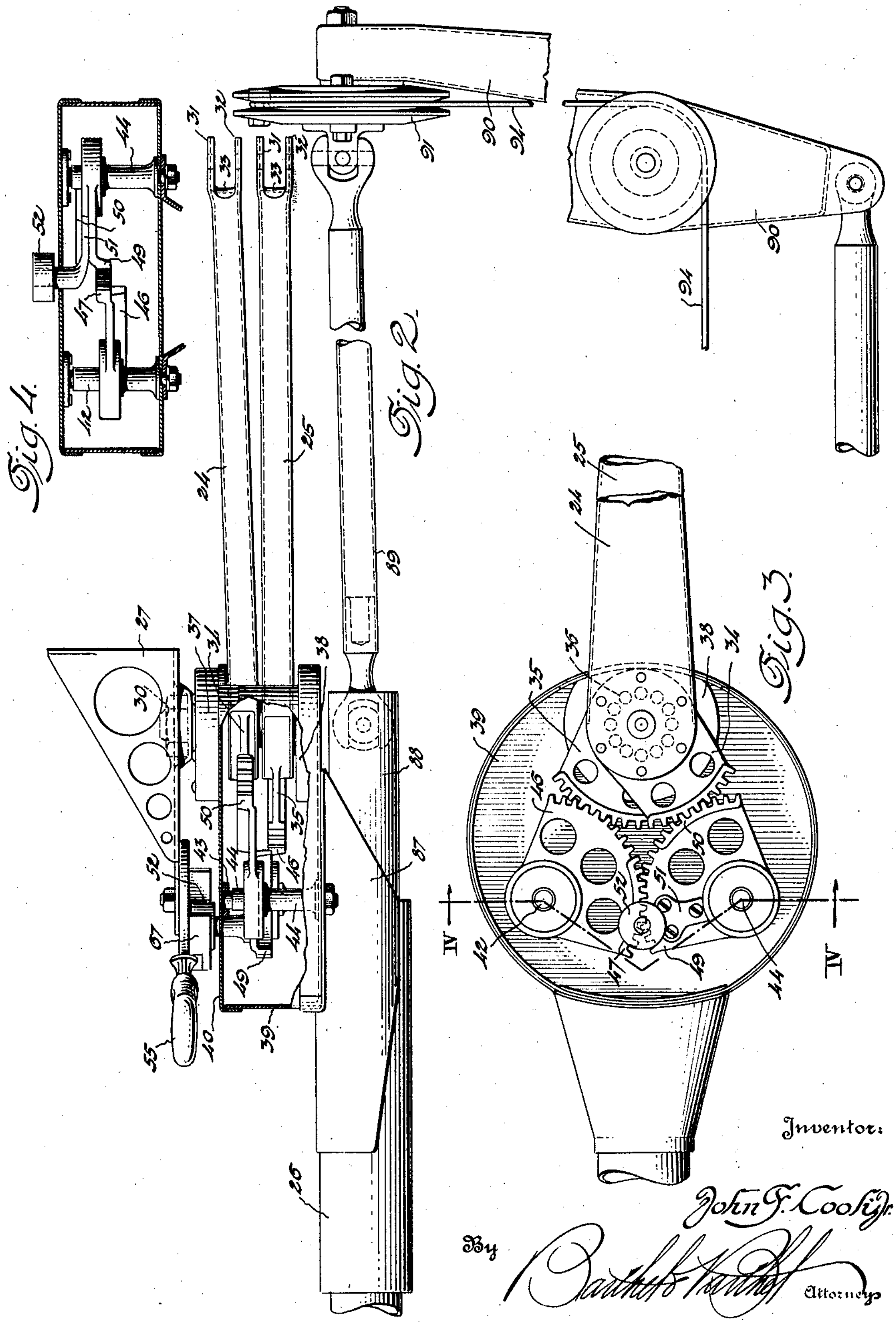

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AIRPLANE

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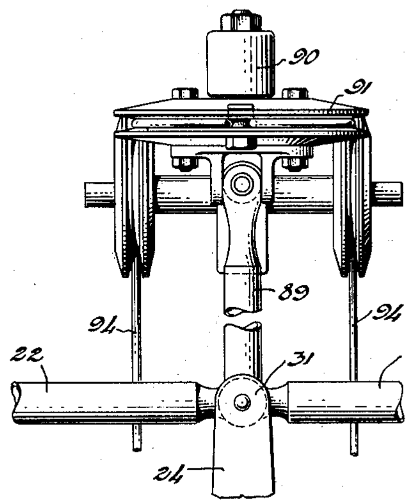
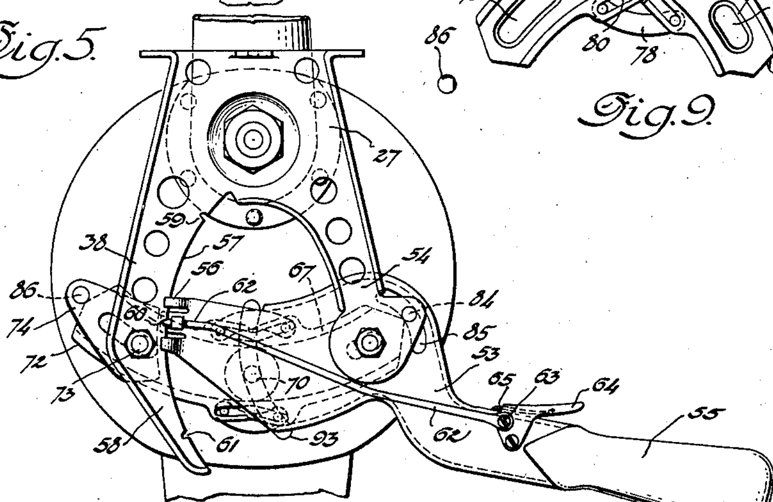


Fig. 5.



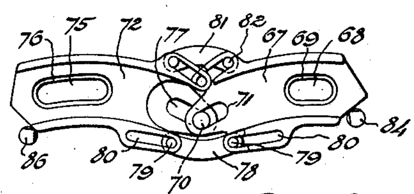


Fig. 8.

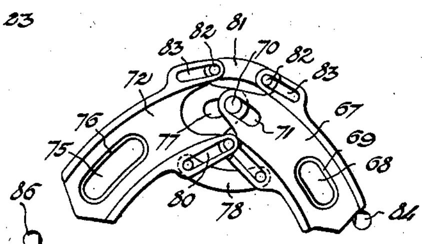


Fig. 9.

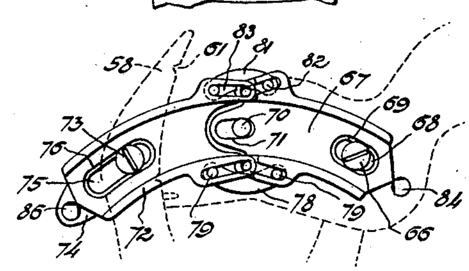


Fig. 6.

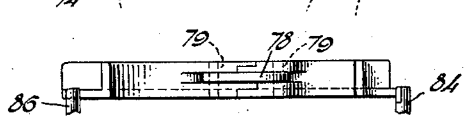


Fig. 7.

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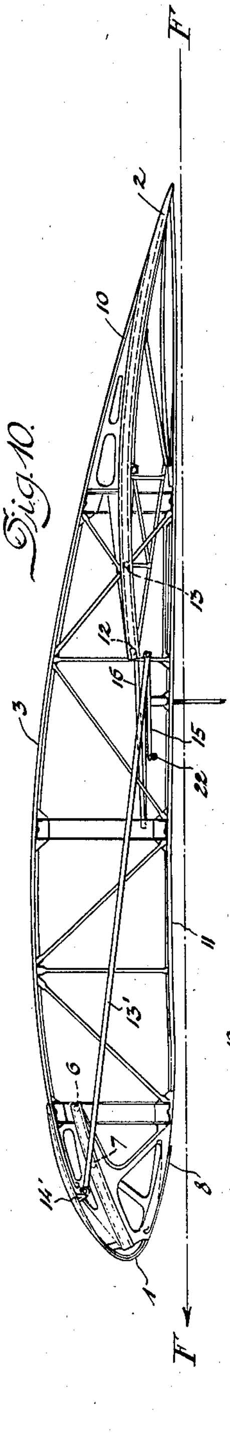

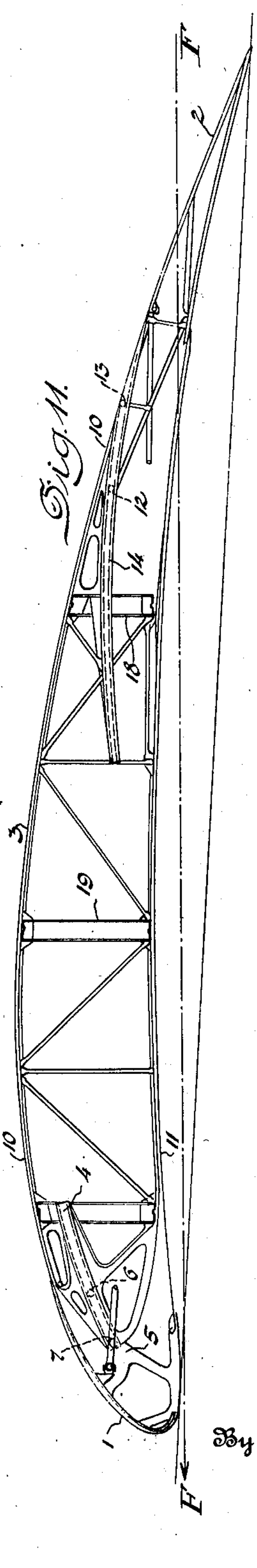

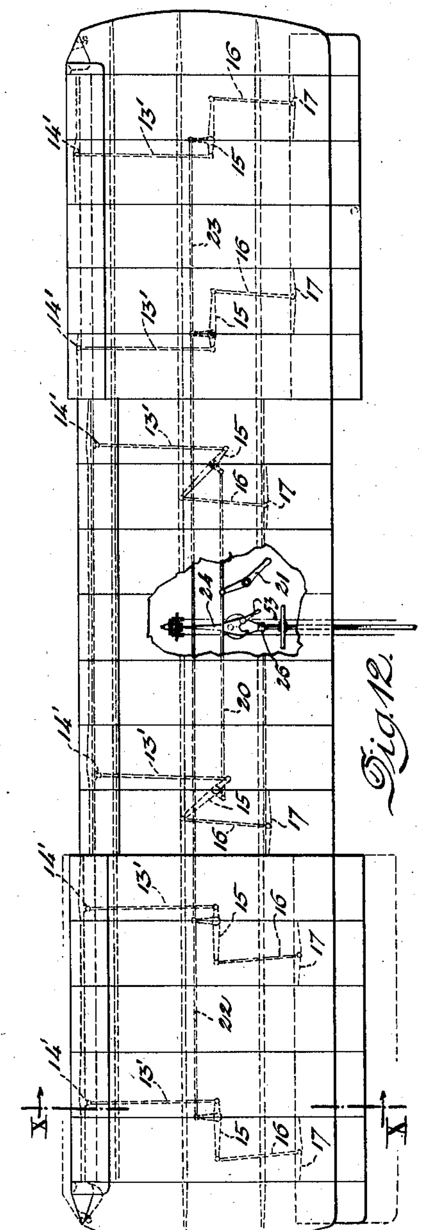

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1,540,104

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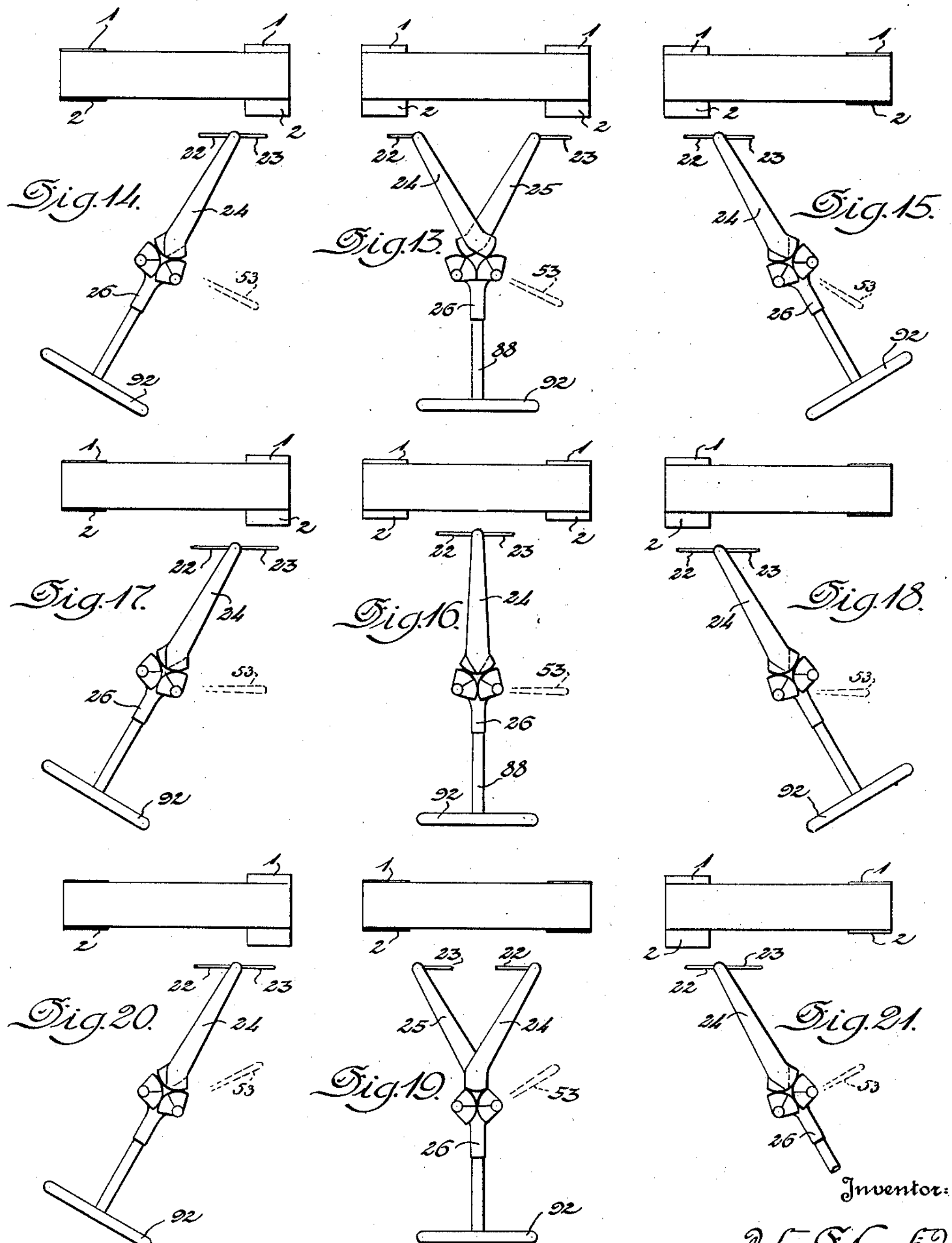

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Patented June 2, 1925. **1,540,104**

UNITED STATES PATENT OFFICE.

JOHN F. COOK, JR., OF DETROIT, MICHIGAN.

AIRPLANE.

Application filed December 18, 1922. Serial No. 607,538.

To all whom it may concern:

Be it known that I, JOHN F. COOK, Jr., a citizen of the United States of America, residing at Detroit, in the county of Wayne and State of Michigan, have invented certain new and useful Improvements in Airplanes, of which the following is a specification, reference being had therein to the accompanying drawings.

This invention relates to aerofoils, and has for its principal object the provision of an airplane having aerofoils in which the left is relatively variable upon opposite sides of the fuselage whereby lateral control may be obtained by varying the relative lift upon the different sides.

A further object of the invention is to provide means by which the cross section of the aerofoil may be changed during flight from a configuration suitable for high speed to a configuration of deeper camber suitable for low speed and having a high lift value at high angles of incidence.

It has for another object the provision of an aerofoil having a low camber of high efficiency at small angles of incidence and high speed, in which the camber may be modified with a simultaneous increase in the area of the aerofoil, whereby when the plane is about to land, the area may be increased to a maximum with a simultaneous increase in the maximum lift co-efficient due to the variation in the camber.

A still further object is the provision of an aerofoil of variable area in which the angle of incidence is increased simultaneously with the increase in area, whereby to increase the lift while maintaining the propeller of the air plane with its axis substantially parallel with the line of flight to obtain a greater efficiency of the propeller.

Other and further objects of the invention will appear in connection with the description of the device, reference being had to the accompanying drawings forming a portion of the specification, in which—

Figure 1 is a view in perspective of the planetary gearing used in the operation of the controlling means with portions of the device detached and lifted away from the casing containing the gearing;

Fig. 2 is a side elevation of the controlling mechanism, parts being broken away;

Fig. 3 is a plan view partly in section of the central portion of the control mechanism, the upper portion being removed;

Fig. 4 is a transverse section on the line IV—IV of Fig. 3, looking in the direction indicated by the arrows, the gears being shown in elevation;

Fig. 5 is a plan view of the upper portion of the controlling mechanism, parts being broken away;

Fig. 6 is a bottom plan view of the guide channel members controlling the planetary gearing;

Fig. 7 is a side elevation of the parts shown in Fig. 6;

Figs. 8 and 9 are views similar to Fig. 6, showing the parts in different positions of adjustment;

Fig. 10 is a fore and aft section through an aerofoil with the movable portions retracted to give a configuration suitable for high speed;

Fig. 11 is a similar section showing the movable portions projected to give a configuration suitable for low speed;

Fig. 12 is a diagrammatic plan view of an airplane, portions being omitted and broken away, and

Figs. 13 to 21 inclusive are diagrammatic plan views indicating the relative positions of the movable portions of the aerofoils in various adjustments.

In the aerofoil illustrated in Figs. 10, 11 and 12, a movable nose portion 1 and a movable trailing portion 2 are mounted upon an intermediate portion 3 in such manner that the nose portion 1 may be moved forward and downward on the arc of a circle from the position shown in Fig. 10 to the position shown in Fig. 11, while at the same time the trailing portion 2 is also moved on an arc of a circle from the position shown in Fig. 10 to the position shown in Fig. 11. The details of the structure by which such movement is made possible are more fully described in my co-pending application.

In general, forward guide tracks 4 control the movement of bearing brackets 5 upon which are mounted the rollers 6 and 7. Each bearing bracket 5 forms part of a nose rib whose outer edge has the configuration desired for the forward or leading edge of the aerofoil. Upon these ribs are secured sheet metal covering members 8 which overlap the upper and lower surfaces of the sheet metal members 10 and 11 of the fixed intermediate wing portion 3. The trailing portion 2 has guide rollers 12 and 13 moving in a curved track 14 secured within the intermediate portion 3, and the upper surface of this trailing portion is curved on an arc of a circle concentric with the curved track 14, so that as the trailing portion 2 is moved in and out, the upper surface of the sheet metal covering the trailing portion remains in contact with the rear edge of the sheet metal covering 10.

At the rear, the sheet metal covering 11 is not secured to the framework of the intermediate portion 3, but is free to bend downward as the wedge-shaped trailing portion 2 is projected, the rear edge of the metal covering 11 lying closely in contact with the lower sheet metal covering of the portion 2 at all stages of its movement in or out. The means used to project the nose portion comprises a series of rods 13′ pivoted at their forward ends to brackets 14′ on the nose portion and pivoted at their rear end to the short arms of bell crank levers 15. Similarly, a series of rods 16 are pivoted at their rear ends to brackets 17 upon the trailing portion and at their forward ends to the long arms of the bell crank levers 15. Thus angular movement of the bell crank levers will cause simultaneous movement of the nose and trailing portions in or out, the extent of movement of the rear or trailing portion being about three times that of the forward or nose portion. As will be seen by reference to Fig. 10, the cross section of the aerofoil when the parts 1 and 2 are withdrawn, is suitable for high speed. The camber is low and the angle of incidence to the line of flight F—F is small.

In Fig. 11, it will be seen that while the nose portion 1 has been projected forward and downward with respect to the intermediate portion 3, the rear or trailing portion 2 has been projected downward to a much greater extent and has moved to the rear about three times as far as the nose has moved forward. This downward and outward movement of the portion 2 has caused the bending of the lower sheet metal covering 11 at the rear so that the lower surface of the aerofoil presents a substantially continuous curvature from a point about midway between the trailing spar 18 and the central spar 19 to the extreme rear edge of the trailing portion 2. This greater downward projection of the rear edge has changed the angle of incidence to the line of flight F—F without altering the relative position of the intermediate section 3 to the line of flight.

Not only has the angle of incidence been changed, but the chord has been increased and the camber greatly modified, so that with the increase in area and deepening of camber, as well as with the increase in angle of incidence, the lift has been very greatly increased. The position of the maximum ordinate has moved slightly to the rear which would cause rearward movement of the center of pressure, but the increase in the angle of incidence tends to move the center of pressure forward. The variation in the wing section during the opening movement of the nose and trailing portions will thus result in keeping the center of pressure at substantially the same positions with respect to the center of gravity of the machine. The sheet metal covering of the nose portion overlaps the top and bottom surfaces of the forward end of the intermediate portion, and the sheet metal covering of the intermediate portion overlaps the sheet metal covering of the forward end of the trailing portion when it is fully extended so that at all stages of adjustment of the movable portions there is presented a substantially unbroken curvature of the entire top and bottom surfaces.

The front and rear movable portions of the aerofoil may conveniently be made in three separately movable pairs, those for the right and left panels being connected for simultaneous operation while the intermediate pair of the central panel may be provided with a separate operating means.

As shown in Fig. 12, a rod 20 connects the two bell crank levers 15 mounted within the central panel of the aerofoil, and this rod 20 may be moved to various positions of adjustment by means of a lever 21.

The levers 15 in the two outer panels of the aerofoil are connected by means of a pair of rods 22 and 23, the inner adjacent ends of which are secured to arms 24 and 25, these arms being mounted for independent or simultaneous movement by means of the main control arm 26.

As shown most clearly in Figs. 1 and 2, a bearing bracket 27, preferably formed of sheet steel, is secured to any suitable part of the airplane (not shown). This bracket forms the support for a pivot member 28, the threaded upper end 29 of which is secured to the lower portion of the bracket member 27 by means of a nut 30. The bracket is shown as perforated to reduce its weight.

The arms 24 and 25 are made of sheet steel tubing of substantially elliptical cross section, the forward ends being slit to provide parallel ears 31, 32 to which are pivoted the rods 22, 23. The metal between the ears is folded in and welded at 33 to close the outer ends of the arm and to provide a strengthening partition. At the rear, the arms 24 and 25 are flattened and formed with two parallel rounded ends between which are secured the hub portions of segmental gears 34, 35. Surrounding the center of curvature of the gear segments are ball bearings 36, the race members being mounted upon the intermediate portion of the shaft 28. Upon the shaft 28 above and below the bearings for the segmental gears, are mounted bearings 37 and 38 secured to a casing 39 which forms a closure for the gear train connecting the arms 24 and 25. The upper or lid member 40 is provided with a bearing 41 for the upper end of a pivot member 42, the lower end of which is secured as by a nut upon the bottom of the casing 39. A similar bearing 43 receives the upper end of a shaft 44 also secured upon the bottom of the casing 39. Upon the shaft 42, is mounted a ball bearing 45 for a gear member having a lower segmental gear portion 46 and an upper segmental gear portion 47. Upon the shaft 44, is a ball bearing 48 for a gear member having a lower segmental gear portion 49, and an upper segmental gear portion 50. The segmental gear member 34 upon the arm 24 is in mesh with the segmental gear 50, and the segmental gear 35 upon the arm 25 is in mesh with the segmental gear portion 46. The segmental gear portions 47 and 49 are in mesh with each other, and since the segments 46 and 47 are sectors of the same gear, and are thus rigidly connected, and the gear segments 49 and 50 are similarly sectors of a single gear and rigidly connected, it will be seen that the arm 24 is geared to the arm 25 by the intermediate gear members 46, 47, 49 and 50. A bracket member 51 is secured upon the upper face of the gear segment 49 and upon the upper end of this bracket is journaled a roller 52.

A lever 53 is pivoted upon the bracket arm 54 of the member 27, this lever 53 having a handle 55 upon one side of its pivot, while the other end of the lever is provided with guide fingers 56 above and below the curved edge 57 of the bracket arm 58 formed upon the member 27. The curved edge 57 is a segment of a circle having as its center the pivot of the lever 53, and it is provided with notches 59, 60 and 61 which are engaged by a sliding latch member 62 pivoted at 63 to a thumb piece 64 adjacent to the handle 55, a spring 65 normally acting upon the thumb piece 64 to hold the latch member 62 in engagement with one of the notches in the curved edge 57.

The pivot forming the connection between the lever 53 and the bracket arm 54 is preferably a shoulder bolt having a flat head 66 as shown in Figs. 1 and 6. Upon the under face of the lever 53 is slidably mounted a channeled guide member 67 slotted as shown in Figs. 6, 8 and 9 at 68 to receive the shank of the pivot bolt beneath the head 66. The surface of the guide member surrounding the slot 68 is cut away as shown at 69 to receive the head 66 of the bolt, the head having its outer surface flush with the bottom of the channel formed in the guide member. Upon the lever 53, a little to one side of a point midway between its pivot and the guide fingers, is a stud 70 which engages within a slot 71 formed near the end of the guide member 67 remote from the slot 68. A similar channeled guide member 72 is slidably mounted by means of a bolt 73 upon the lower face of a plate 74 secured to the lower side of the bracket arm 58.

The guide member 72 is provided with a slot 75 in the bottom of the channel to receive the shank of the bolt 73, the material surrounding the slot being cut away as shown at 76 to receive the head of the bolt 73, the end of the head being substantially flush with the bottom of the channel of the guide member 72. At its inner end adjacent to the guide member 67, the guide member 72 is provided with a slot 77 to engage the stud 70. As shown most clearly in Figs. 8 and 9, the end of the member 67 overlaps the end of the member 72, the overlapping end portion of each movable upon the other being reduced in thickness to form a halved joint.

When the lever 53 is in the position shown in Fig. 5, the stud 70 lies substantially equally distant from the pivot 73 and from the pivot of the lever 53, and in this position, the curved channels of the guides 67 and 72 are concentric, forming together a portion of an arc of a circle as illustrated in Fig. 6.

When the latch 62 is withdrawn from the notch 60 and the lever is moved to the position in which the latch will engage within the notch 59, the guide members will lie in a position shown in Fig. 8. It will be seen that in this position there would be a gap between the ends of the side walls of the channel adjacent to the stud 70, and to cover this gap, there is provided a closure member 78, having studs 79 at each end projecting upward and downward for sliding engagement with slots 80 formed within the side walls of each of the guides 67 and 72.

When the lever is moved to the position in which the latch 62 engages in the notch 61, the guide members 67 and 72 will lie in the position indicated in Fig. 9, and to close the gap which will exist between the side walls on the opposite side of the stud 70 from the member 78, there is provided a closure member 81 having studs 82 lying within slots 83 formed in the side walls of the channeled guides 67 and 72 opposite the slots 80. Projecting downward from the bracket arm 54 is a stud 84, a slot 85 being formed within the lever 53 to receive the stud while permitting pivotal movement of the lever. The stud 84 projects far enough below the surface of the lever 53 to engage with the outer end of the sliding channel member 67, and a similar stud 86 projects downward from the plate 74 to engage against the outer end of the sliding member 72.

When the lever 53 lies in the intermediate position shown in Fig. 5 with the latch 62 in the notch 60, the outer ends of the channeled guides lie in contact with the studs 84 and 86, with the stud 70 at the inner end of the slots 71 and 77. When the lever is thrown to the rear toward the position in which the latch 62 engages in the notch 59, the channeled members move from the position in Fig. 6 to that shown in Fig. 8. As the upper portions of the two curved members move inward between the pivot of the lever and the pivot 73, the outer ends of the channeled members are forced apart. The studs 84 and 86 are beveled and the outer ends of the channeled members are correspondingly beveled to permit free sliding movement of these members while guiding them accurately into their new position of adjustment. Similarly when the guide members 67 and 72 are in the position shown in Fig. 9 and the lever is moved toward the central position, the beveled outer ends of the members 67 and 72 co-act with the studs 84 and 86 to slide the plates inward and guide their movements to produce smooth operation of the parts.

When the parts shown in Fig. 1 are assembled as shown in elevation in Fig. 2, the roller 52 lies within the guideway formed by the channeled members 67 and 72, and when these channeled guides lie in the arc of a circle as shown in Figs. 1, 5 and 6, the arms 24 and 25 lie parallel as indicated in Fig. 1.

The bracket member 27 is secured to some fixed part (not shown) of the airplane, and the stud 28 is rigidly secured to the bracket. The casing 39 with the arms 24 and 25 and their connecting segmental gears may therefore be rotated about the axis of the shaft 28 in the bearings 37 and 38. For this purpose, the main control arm 26 is firmly secured to the casing by means of an expanded end member 87. The control arm 26, as shown in Figs. 1 and 2, is formed as a cylindrical tube within which is slidably and rotatably mounted the tubular shaft 88 to the forward end of which is jointed the rod 89 having at its forward end pivotal connection with the lever 90, and having mounted thereon a pulley 91, the lever 90 and the pulley 91 forming a part of the usual operating means for the rudders used for vertical and horizontal control of the airplane. At the rear end of the shaft 88, a hand wheel 92 will be provided as indicated in Figs. 13 to 21.

The lid portion 40 of the casing 39 is provided with a slot 93 concentric with the pivot 44, the slot 93 permitting the movement of the bracket arm 51 which extends to a point above the lid member 40 as shown in Fig. 2, with the roller 52 engaged within the channeled guides. The arc of a circle formed by the channeled guides in the position shown in Fig. 6 is concentric with the shaft 28, and it will thus be seen that as the arm 26 is swung around the shaft 28, the roller 52 will travel within the circular arc formed by the channeled members, and there will be no relative movement of the arms 24 and 25, since the roller 52 is journaled upon the bracket 51 rigidly connected to the gear member 49.

Movement of the rod 22 to the left in Fig. 12 will act upon bell crank levers 15 to cause the movable nose and trailing portions of the left panel of the aerofoil to be projected, while movement of the rod 23 to the left in the same figure will act upon other bell crank levers to cause retraction of the nose and trailing portions of the right panel of the aerofoil. The length of the rods 22 and 23 is so adjusted that when the arms 24 and 25 are parallel with each other and extending directly to the front as indicated in Figs. 12 and 16, the nose and trailing portions of the outer panels of the aerofoil of both sides of the fuselage are each half way projected. Simultaneous movement of the arms 24 and 25 to the right as indicated in Fig. 17 will cause outward movement of the nose and trailing portions upon the right side of the airplane, and simultaneous inward movement of the nose and trailing portions upon the left side of the airplane. Similarly, simultaneous movement of the arms 24 and 25 to the left as indicated in Fig. 18 will cause projection of the movable portions upon the left side of the airplane, and simultaneous retraction of the movable portions upon the right side of the airplane.

Movement of the lever 53 forward will cause movement of the channeled guides 67 and 72 to the position shown in Fig. 9, and this will cause rearward movement of the roller 52 with a corresponding movement of the segmental gears within the casing 39. As the gear segments 47 and 49 swing toward the rear, the arm 24 will be swung to the right and the arm 25 will be swung to the left into the position indicated in Fig. 19. This movement of the arms 24 and 25 will cause simultaneous retraction of the movable portions 1 and 2 of both outer panels. If the wheel 92 is moved to the left to the position shown in Fig. 20, the arm 24 being already at its outmost position of movement to the right, cannot swing further, but remains relatively fixed. The gear segment 50 in mesh with the gear segment 34 upon the arm 24 will therefore roll upon the gear 34 as the pivot 44 moves around the shaft 28. This will cause forward movement of the roller 52 in a curve which is the resultant of its movement about the pivot 44 and its movement about the shaft 28. Through a range of movement of about thirty degrees, this curve will not depart materially from the arc of a circle formed by the channel within the member 72, and any variation from this curve will cause a corresponding movement of the arm 24. It is to be noted however, that the movement of the arms 24 and 25 is dependent upon the movement of the gears and not conversely and the movement of the gears is dependent upon the movement of the roller 52.

Movement of the arm 26 to the right, from the position shown in Fig. 19 to that shown in Fig. 21, will cause movement of the arm 24 to the left to a position above the arm 25 with a corresponding projection of the portions 1 and 2 from the left hand panel of the aerofoil, and the roller 52 will move along the curved channel in the member 67 in a manner precisely similar to its movement in the channel 72 when the wheel is moved in the reverse direction.

Movement of the lever 53 rearward will cause movement of the channeled guides 67 and 72 to the position shown in Fig. 8, and this will cause forward movement of the roller 52 with a corresponding movement of the segmental gears within the casing 39. As the gear segments 47 and 49 swing forward, the arm 24 will be swung to the left, and the arm 25 will be swung to the right into the position indicated in Fig. 13. This movement of the arms 24 and 25 will cause simultaneous projection of the movable portions 1 and 2 of both outer wing panels. If the wheel 92 is moved to the left from the position shown in Fig. 13 to the position shown in Fig. 14, the arm 26 and the casing 39 participating in the movement, the arm 25 being already nearly at its extreme range of movement to the right, will remain substantially fixed. If the gear segment 35 were fixed, the gear segment 46 would roll upon the segment 35 as its pivot 42 moves around the shaft 28. This would cause rearward movement of the gear segment 47 and of the segment 49 with which it is in mesh with a corresponding movement of the roller 52. This combined movement toward the rear about the pivot 44 and to the left about the pivot 28 will cause the roller 52 to move in a curve which is the resultant of its movement about both pivots, and this curve will not differ materially from the arc of a circle formed by the channel within the member 72, and since variation from this curve is impossible, the roller lying between the sides of the channel member, the arm 25 will move slightly in one direction or the other to compensate for the difference between the curve that would be taken by the roller 52 if the gear 35 were fixed, and the curve which it must take because the roller 52 is constrained to move within the channel member 72. Through a range of movement of about thirty degrees, these curves are substantially identical and the arm 25 will therefore remain substantially stationary, while the arm 24 will be moved from the position shown in Fig. 13 to that shown in Fig. 14 at a rate of speed double that of the movement of the arm 26. Movement of the wheel 92 and arm 26 to the right from the position in Fig. 13 to the position shown in Fig. 15 will cause movement of the arm 25 to the left at a rate of speed double that of the movement of the arm 26, with a simultaneous projection of the parts 1 and 2 from the left panel of the aerofoil.

In Fig. 16, the lever 53 is in the intermediate position indicated in Fig. 5, with the latch 62 in the notch 60, and the arm 24 lies directly above the arm 25. As has been stated above, the rods 22 and 23 are of such a length that in this position of the arms 24 and 25, the nose and trailing portions of the outer panels of the aerofoil on both sides of the fuselage are each half way projected. When the lever 53 is swung to the rear as indicated in Fig. 13, to a point at which the latch 62 engages the notch 59, the nose and trailing portions 1 and 2 will simultaneously be projected upon both the outer panels of the aerofoil. When the lever 53 is moved to the forward position, in which the latch 62 engages the notch 61, the nose portion 1 and trailing portion 2 will simultaneously be retracted in the outer panels on both sides of the fuselage. In the central position of the lever indicated in Fig. 16, the arms 24 and 25 are parallel and remain parallel during the entire swinging movement of the arm 26 to either side, the movements of the movable portion of the outer panels being equal in amount but opposite in direction, so that as one wing expands, the other contracts. When the lever 53 is forward as shown in Fig. 19, the movable portions 1 and 2 are retracted on opposite sides of the fuselage which is the position in which the aerofoil is best suited for high speed. During movement of the control arm 26 to either side from the central position, the wing area upon the opposite side increases, while the wing panel upon the side toward which the arm 26 is moved remains with its movable portions in retracted position.

When the lever 53 is in the rearward position shown in Fig. 13, with the movable portions on both outer panels projected, movement of the control arm 26 to either side will cause retraction of the movable portions 1 and 2 on the side toward which the arm 26 is moved, the movable portions

1 and 2 on the opposite side remaining projected.

It will be observed that complete movement of the control arm 26 to the left as indicated in Figs. 14, 17 and 20, results in each case in an identical position of the movable parts 1 and 2 regardless of the position of the lever 53 and similar movement of the control arm to the extreme right as shown in Figs. 15, 18 and 21, results in identical position of the movable parts 1 and 2. In each case, the relative difference of area upon the two outer panels of the aerofoil caused by movement of the arm 26 will be the same for equal movement of the control arm 26 regardless of the adjustment of the lever 53. In the intermediate position indicated in Fig. 16, with the movable portions 1 and 2 half way projected on both sides, increase of area on one side is accompanied by a corresponding decrease of area on the opposite side. In the retracted position of the movable parts indicated in Fig. 19, movement of the control arm to either side will cause increase of area of the outer panel upon the opposite side, but this increase in area will be twice as rapid for any given angle of movement as is the case from the intermediate position of Fig. 16. Similarly, movement of the control arm from the position shown in Fig. 13 to either side, causes retraction of the movable portions upon the side toward which the arm is moved, and this retraction occurs at double the rate of speed at which retraction occurs from the intermediate position shown in Fig. 16.

From this it results that the lateral control of the aerofoil is obtained by precisely the same amount of lateral movement of the wheel 92, either with the outer panels fully expanded by the projection of their movable portions 1 and 2, (which is the position in which the aerofoil has its greatest area and deepest camber and hence its maximum lift), or with its movable portions fully retracted, (which is the condition rendering the aerofoil most efficient for high speed), and this lateral control is obtained at all positions of adjustment of the movable sections, without substantial change in the position of the center of pressure.

The movement to be made by the aviator in controlling the airplane by means of the wheel 92 is thus the movements which would instinctively be made by one familiar with the use of a wheel in directing the movement of a boat or an automobile. Rotation of the wheel 92, causing rotation of the shafts 88 and 89 and the pulley 91, will act through the cables 94 to move the vertical rudder for right or left movement, this being the same movement of the wheel as is used in guiding an automobile or boat. Rearward movement upon the wheel 92, causing sliding movement of the rod 88 within the arm 26, will swing the lever 90, and this swinging movement will act upon the horizontal rudders or elevator to cause upward movement of the airplane. If the aerofoil tilts downward to the right, the aviator will instinctively move to the left, thus moving the wheel 92 to the left. This will cause the area of the right panel of the aerofoil to become greater than the area of the left panel and consequently the upward pressure on the right panel will become greater than that on the left so that the airplane will regain its equilibrium.

For climbing, the aviator will start from rest with the nose and trailing portions fully retracted to decrease the resistance to the miniumum. This will give the high speed section with the minimum camber and the minimum angle of incidence. Thus the airplane may quickly attain such speed in running along the ground for a short distance that if the nose and trailing portions are rapidly projected, the increased area, increased camber, and increased angle of incidence will produce substantially instantaneously a sufficient lift for take-off at tne speed already attained, thus shortening the necessary travel along the ground.

After the airplane has reached a sufficient height, the lever 21 may be moved to retract the movable nose and trailing portions of the central panel or panels of the aerofoil without change in the position of the movable portions of the outer wing panels. The central portion of the aerofoil will thus assume a camber suitable for higher speed, and as the speed increases, the operator may move the lever 53 to retract the movable portions 1 and 2 of the outer wing panels to the position indicated in Fig. 19, so that the entire aerofoil assumes the most efficient camber for high speed. At the same time lateral stability is obtained by such slight movements of the control arm 26 as are necessary to project the movable portions upon either wing to vary the lift upon the opposite sides.

For landing, the lever 21 will be moved to project the nose and trailing portions of the central panel or panels of the aerofoil, and the lever 53 will be moved to the rear to project the nose and trailing portions of the right and left outer panels of the aerofoil. This will give an increase in wing area of approximately thirty-three per cent with the aerofoil sections illustrated in Figs. 10 and 11. This increase in wing area is accompanied by a change from the high speed section of Fig. 10, to the low speed section of Fig. 11, which will have a camber calculated to give a maximum efficiency for landing. The greater downward projection of the trailing portion as compared to the downward movement of the nose portion will increase the angle of incidence of the aerofoil without alteration in the relative position of the central portion 3 with respect to the axis of the propeller. At the same time, in spite of the movement of the nose and trailing portions outward from the fixed portion 2, the upper and lower surfaces of the aerofoil remain substantially smooth with a minimum discontinuity of curvature. These factors contribute to utilize the full power of the propeller to obtain a large lift at the lowest possible speed.

After the wheels have come into contact with the ground, the nose and trailing portions may be retracted to decrease the lift and thus to throw the weight upon the wheels, whereby to render the action of brakes upon the wheels more efficient. If, however, the aviator wishes to utilize the resistance due to the large wing area at a high angle of incidence to check his movement, the movable portions will be left projected to their outer limit and the aerofoil will be tilted to the maximum angle of incidence.

It is of course obvious that in landing and in the take-off, greater angles of incidence will be used than are obtained by the mere variation in the projection of the nose and trailing portions, but since the complete projection of the trailing portion lowers its rear edge below the lower edge of the nose portion to increase the angle of incidence by about four degrees in the sections illustrated, the amount of tilt necessary to be given to the fuselage will be about one-third less than if the trailing portion were not projected downward in its outward movement.

It will be evident that the variation in the chord will cause a change in the aspect ratio, there being a higher aspect ratio in the high speed position in which the angle of flight will be low, and this higher aspect ratio will result in a better lift/drift ratio.

From the foregoing description it will be seen that there has been provided an aerofoil in which the stream line of the cambered surface is not maintained but is varied from a configuration efficient for speed to a configuration efficient for lift, and while the curvature of the upper surface of the trailing portion is not similar to that of the top of the fixed section but is an arc of a circle, and while the curvature of the upper surface is not maintained as the trailing portion is projected, actual wind-tunnel tests have demonstrated that the double camber section produced by projecting the trailing portion is highly efficient.

While the method of controlling the equilibrium of the airplane herein disclosed is preferred because of its many advantages, it is obvious that the controlling mechanism disclosed may be applied to any airplane construction in which variation in the position of a movable part alters the lift upon opposite sides of the fuselage. It will be understood that the construction herein shown is merely illustrative and that many variations in form and proportion may be made and equivalent mechanisms substituted therefor without departing from the principle of the invention or sacrificing any of its advantages. The invention is therefore claimed broadly within the full and ligitimate scope of the appended claims.

I claim:—

1. An aerofoil having an initial section designed for the purpose of giving a high lift/drift ratio and provided with nose and trailing portions capable of being simultaneously projected or retracted for the purpose of varying the angle of entry and trail simultaneously, connecting rods pivoted at one of their ends to said nose and trailing portions and connected at their other ends to bell crank levers, links connected to said levers adapted to move said levers simultaneously, and controlling means connected with said links adapted to cause simultaneous projection or retraction of said nose and trailing portions upon opposite sides of said aerofoil.

2. An aerofoil having an initial section designed for the purpose of giving a high lift/drift ratio and provided with a nose portion adapted for projection forward and downward and a trailing portion adapted for projection rearward and downward, link rods connecting the nose and trailing portions with a bell crank lever, and a link connecting said bell crank lever with a controlling means adapted to cause simultaneous projection or retraction of the nose and trailing portions on opposite sides of the airplane, and additional operating means co-operating with said first named means for varying the relative extent of projection of said nose and trailing portions upon opposite sides of the aerofoil.

3. An aerofoil having an initial section designed for the purpose of giving a high lift/drift ratio and provided with nose and trailing portions capable of simultaneous projection forwardly and rearwardly respectively, the extent of movement of the trailing portion being greater than that of the nose portion and the movement of the front edge of the nose portion and the rear edge of the trailing portion being downward, the curvature of the upper surfaces of the nose and trailing portions being such that in their position of extreme projection the upper surface of the aerofoil has a greater camber than in the initial position, the lower surface of the aerofoil being formed of flexible sheet metal portions of which metal are free to flex and co-operate

with the lower surfaces of the nose and trailing portions to provide a substantially continuous lower surface, the curvature of which surface is changed by the operation of said nose and trailing portions.

4. In an airplane having movable lateral control members, of means for controlling the operation of said members including swinging arms operatively connected to said control members to operate the same, means connecting said swinging members to swing the same, and means for setting said swinging members relatively to vary the initial relative setting of said lateral control members for operation by said connecting means.

5. In an airplane having on opposite sides nose and trailing portions movable inward and outward from a fixed position to vary the lift for the control of equilibrium, a pair of swinging members operatively connected to said nose and trailing portion to operate the same, connecting means for connecting said swinging members for simultaneous movement, an operating member for swinging said swinging members, and means for setting said swinging members relatively for varying the operation of said nose and trailing portion by said operating member.

6. An airplane comprising oppositely extending wings, each wing being provided with nose and trailing portions capable of being projected and retracted, means for causing simultaneous projection or retraction of the movable sections in both wings, and additional means co-operating with said first named means for varying the relative amount of projection of the movable portions upon opposite wings for lateral control.

7. In an airplane wherein movable elements cause variation in lift on opposite sides for control of equilibrium and wherein a control member is movable to control vertical and horizontal rudders, means operatively connected with said control member for movement thereby to cause movement of said movable elements, and differential mechanism forming part of the control means to permit independent movement of, or variation in relative movement of, the lift-control members, whereby in one position of adjustment both wing elements are in a position of small lift and either wing is movable to increase lift, in another position both are in position of greater lift and either is movable to reduce the lift, and in an intermediate position as one wing increases in lift the other decreases in lift.

8. In an airplane wherein elements on opposite sides are movable to vary the lift from a maximum to a minimum and wherein an intermediate differential mechanism comprising gearing having controlled movement in one position of adjustment permits simultaneous movement of elements on opposite sides in reverse directions to vary the relative lift, and in another position of adjustment permits either to be moved from a position of less lift to a position of greater lift while the other remains substantially fixed, and in another position permits either member to be moved from a position of greater lift to one of less lift while the other remains substantially fixed, means for controlling the gearing comprising a guide determining the relative movement of the periphery of one of the gears with respect to the movement of its pivot.

9. In an airplane having on opposite sides nose and trailing portions movable inward and outward from a fixed portion to vary the lift for the control of equilibrium, movable control elements for opposite sides connected by a differential mechanism including a gear, and a guide determining the movement of the periphery of said gear during movement of the control elements.

10. In an airplane wherein separately movable elements capable of movement between limits cause variation in lift on opposite sides, controlling elements for said movable parts, an intermediate gear train operatively connected with said controlling elements, said gear train having members mounted for movement of their axes, and control means determining the relative movement of the periphery with respect to the movement of the axis of one of said members.

11. In an airplane, portions movable on opposite sides to vary the lift, an intermediate gear train operatively connecting the movable elements, some of the gears of the train being capable of movement of translation, an adjustable guide, one of the gears having a portion thereof guided in its movement by said guide, means for adjusting said guide to cause variations in the movement of said gear train, and control means for moving said gear train, whereby the relative position of the movable portions of the airplane may be varied.

12. In a control device for varying the total lift of the wings of an airplane, and for varying the relative lift of opposite wings for control of equilibrium, operating means for producing movement of the lift-varying elements on opposite wings, a differential gear mechanism interposed between said operating means, and adjustable means for controlling the movement of said differential mechanism, whereby in one position of adjustment the total lift will be relatively small and in another position of adjustment the total lift will be relatively large, the differential mechanism permitting variation in the relative lift on opposite sides at all positions of adjustment of the total lift.

13. In an airplane wherein oppositely dis-

posed wings have portions movable to vary the lift and wherein the movement of said portions is controlled by a mechanism which also controls the rudders for vertical and horizontal guidance of the airplane, members operatively connected to the movable portions of the wings, a gear train connecting said members, and means for causing bodily movement of part of said gear train to produce relative movement of said members, and adjustable guiding means determining the relative movement of the periphery of one of the gears of the train with respect to the movement of its axis.

14. In an airplane having vertical and horizontal rudders and members for controlling the lift of opposite wings, a movable control element for the vertical and horizontal rudders, a differential gearing having a gear thereof movable by the rudder control means, a guide means adjacent to the path of movement of said gear, and an element on said gear operatively connected with said guide means to determine the movement of the periphery of said gear during movement of its pivot, said guide means being adjustable from a position in which the lift-control members operate oppositely in effect but in substantially equal amount on opposite sides, to a position in which either lift-control member may be operated during substantially no movement of the other and in which the extent of movement of the member is substantially double that during simultaneous movement of both members, whereby to produce equal effects for equal movements of the control element at all positions of adjustment.

15. In an airplane wherein oppositely disposed wings have portions movable to vary the lift, a support, a pivot on said support, control members extending from said movable portions toward the support, control arms to which said control members are operatively connected, said arms being pivoted on said pivot, a gear on each arm concentric with said pivot, intermediate gears in mesh therewith mounted for rotation about said pivot, and means for moving said gears.

16. A structure as in claim 15, in which guiding means on said support controls the movement of the periphery of one of said intermediate gears.

17. A structure as in claim 15, in which guide means on the support engage means on one of the intermediate gears to vary its position whereby to vary the total lift of the wings, said guide permitting movement of said gear and controlling the movement of its periphery to vary the relative lift on opposite sides for controlling the equlibrium of the airplane.

18. In an airplane, oppositely disposed wings, each having a portion movable to vary the lift, a support, a pivot on said support having control arms pivotally mounted thereon, a gear on each arm concentric with said pivot, a casing mounted on said pivot, gears pivotally mounted on said casing in mesh with each other, one of the gears on the casing being in mesh with a gear on one of the arms and another of the gears in the casing being in mesh with the gear on the other arm, means for moving the casing on said pivot, means for moving said gears in said casing comprising movable guides on said support and guide means on one of the gears in the casing cooperating with said movable guides to determine the angular movement of the gears about their pivots and hence the angular movement of the arms relative to the casing, whereby when the guides are concentric with the pivot the arms will move simultaneously in the same direction and when the guides are not concentric with the pivot, the rate of movement of one arm will be different from that of the other.

In testimony whereof I affix my signature in presence of two witnesses.

JOHN F. COOK, Jr.

Witnesses:
Arthur Minnick,
G. L. Terna.