N° 8118 A.D. 1909

Date of Application, 5th Apr., 1909

Complete Specification Left, 4th Oct., 1909—Accepted, 31st Mar., 1910

PROVISIONAL SPECIFICATION.

Improvements relating to Aeroplanes.

I, JOHN WILLIAM DUNNE, Gentleman, of 16, Charing Cross, London, W.C., do hereby declare the nature of this invention to be as follows:—

The object of the present invention is to obtain a form of aeroplane which by virtue solely of the arrangement and form of its supporting surfaces possesses when properly ballasted automatic stability in still air, and also, without requiring any alteration of its centre of gravity or of its surfaces, in very high winds; further, to so construct the aeroplane that it possesses in calm and in agitated air a large measure of freedom from oscillation, a quality quite distinct from that of stable equilibrium, and also to obtain large pressure reactions when the aeroplane is driven at an angle against the air.

The invention consists in constructing each of the main supporting surfaces as a rearwardly projecting wing whose upper face may be defined as traced by a straight line travelling on two guide curves so arranged that the resulting surface swept out is convex towards its upper side in all sections taken fore and aft and laterally, the angle of the incidence gradually decreasing from the centre to the ends of the wings, the lower faces of the wings being preferably concave to their lower side.

It will be understood that in the present specification, where not otherwise specified, the surfaces of the wings referred to are the upper surfaces, the lower surfaces being preferably concave, although plane or even convex portions may occur where such are advisable by reason of considerations such as the strength of the structure. It will also be understood that the expression "angle of incidence" in the fore and aft direction means in the case of a plane surface the angle made by the fore and aft section of that surface with the line of flight; in the case of a curved surface the angle made by the line of flight with a straight line drawn from front end to rear end of the curve exposed by a cross section.

The invention more specifically consists in forming the upper faces of the rearwardly projecting main supporting wings or the outer portions thereof as portions of the surfaces of cones of cylinders, the angle incidence of said wings decreasing towards the tips.

The invention also consists in a form of aeroplane in which the main supporting surfaces are in the form of rearwardly projecting wings, the wings or the outer portions thereof forming parts of the surfaces of cones whose apices are towards or outside the rear ends of the wings.

The invention also consists in the improved constructions of aeroplane hereinafter described.

In order to obtain large pressure reactions when the aeroplane is driven at an angle against the air the lifting surfaces must be convex on the upper side and preferably concave on the under side. Further, the machine should be supported by either a single pair of main wings, one wing on each side, or by two such systems placed one above the other as the addition of any further surfaces tends to reduce the efficiency of the whole.

In order to maintain fore and aft stability, I have found it advisable that

[*Price 8d.*]

the whole or the outer part of each wing should have its leading edge so sloped backwards and outwards that the tips of the wings come behind the centre of gravity of the apparatus.

I find that in plan the angle of inclination of the wings to the line of flight should be between the limits of 40° and 70°.

It is advisable that the tips of the wings should be inclined at a smaller angle of incidence than are those portions which are situated further inwards and forwards so that when the mean angle of incidence of the whole system becomes from any cause very small, the wing tips meet the air at a negative angle.

In order to render the machine free from oscillation, it is advisable that as the wing extends outwards the angle of incidence should decrease gradually so that there may be no abrupt alteration of angle at any part of the wing. With a wing so formed alterations of the mean angle of incidence bring into play gradual alterations in the pressures on the wings tending to gently correct the deviation from normal conditions. It is of the greatest importance that this correction should be gentle at the commencement of an oscillation, and it is equally important that the tendency should persist through wide ranges of variation in the mean angle of incidence and increase as the departure from the normal conditions increases. This latter condition involves that the difference between the angles of incidence of the inner and outer portions of the wing should be considerable.

I have found that twisting the wings or rendering them flexible so that they twist under air pressure, to cause the tips to present the requisite small angle, involves the disadvantage that sections taken fore and aft across the tips of the wings or from the inner portion to the tip give curves concave on their upper sides, thus greatly detracting from the lifting powers of the wing. A twisted wing therefore is unable to give large pressure when driven at an angle against the air. I have found further that when such twisted wing changes its mean angle of incidence the changes thereby brought about in the pressures on the outer portions which are concave on their upper sides, occur far too abruptly for steadiness, and in very high winds may produce a condition of unstable equilibrium. Also that the similar concavity on the lateral cross section of the wings gives lateral instability in disturbed air. This form of wing therefore is not suitable.

In order to obtain the correct form therefore it is necessary to consider,

Firstly, how the angle of the fore and aft sections can be made to gradually decrease as the wing is built outwards without producing points of inflexion in the surfaces.

Secondly, how considerable differences in the angles of the inner and outer portions can be maintained without too much loss of pressure under the outer portions and therefore loss of lifting power.

According to one modification of the invention the straight line travels over two guide curves in such a manner that throughout its motion its approximate direction is towards a point situated towards or without the rearmost point of the wing. In this case the surface traced out must approximate to the surface of a cone, a cone being defined in the wide sense as a solid contained by a straight line which always passes through a fixed point and some point on a fixed curve.

If then the guide curves be made concave towards their under sides the whole surface so traced out will be concave below and convex above.

Further, if the shape of the wing in plan be properly selected the angles of incidence of the fore and aft section of such wing will be gradually lessened as the wing is built outward. It will be evident therefore that this form of wing fulfils one of the necessary conditions of the problem.

Again, when a wing of the form described is driven against the air at a small mean angle of incidence, the air owing to the larger angle of incidence of the inner and forward portions of the wing is driven slightly outwards as well as

downwards, the less inclined portions of the wing towards the tips thus having air forced under them in a sideways direction from the inner portions and so compensating to a considerable extent for the imperfect air supply from the normal front direction due to the small or even negative angle of inclination.

Again, it will be seen that the whole of the under surface of the wing may be considered as formed of a number of straight channels converging towards the apex of the cone or as comprising a portion of the inner surface of a pipe which gradually narrows towards the point. There is a tendency therefore not only to force the air outwards along these channels or pipes but also to compress it thereby increasing the pressure under the outer portions, and thus adding further to the lift under these portions compensating for the lack of lift initially due to the small or negative angle of incidence. The feed of air from the inner or forward portions towards the outer portions and the compression of the air under the outer portions enables the outer portions to be placed at a very much smaller angle of incidence than the inner portions without incurring serious loss of lifting power. This form of wing therefore completely solves the problem, and is the form which I prefer to use.

I have found by practical experiment that a machine supported mainly by wings of which the whole or the outer portions are inclined backward as described and constitute portions of the surfaces of cones as described fully satisfies the conditions of stable and steady flight.

According to another form of the invention the straight line travelling over its guide curves is always directed towards a point situated at or in front of the leading point of the wings, and in such case the wings form portions of the surfaces of cones having their apices directed forwards and inwards. In this form lifting power is sacrificed to increased steadiness.

Further between the two forms of the invention above referred to intermediate forms may be employed in which the line moves more nearly parallel to itself, such intermediate forms permitting different degrees of stability and lifting power to be attained.

In the above description, I have considered the supporting surfaces, for the most part neglecting thickness; but it will be evident that a certain thickness of the wings is necessary. The most important consideration, however, is the smoothness and form of the upper surface. In constructing the wings, however, the lower surface is preferably swept out in a similar manner to the upper surface. The positions of the cone apices, however, are different, as otherwise the edges of the under surface would not approximate to those of the upper surface. In a double surface wing, therefore, I prefer to trace the upper surface as above described, and to describe the lower surface in a similar fashion, the path of the travelling line forming the lower surface being so chosen that the front and rear edges come as close as possible to those of the upper surface. One or both the surfaces is or are then eased off, until the edges are made to correspond, the alterations being so made that smoothness and regularity are preserved as much as possible. It may however, be advisable to subordinate the regular coning of the under surface to considerations of the best position for the thicker parts of the wing. In constructing a machine on this principle, the upper surface will be properly swept out by the straight line, as above described, while the lower would simply lie along the bottom of properly shaped ribs. It will be seen, however, that the exact form of the under surfaces may be varied very considerably, the essential feature of the invention being the proper formation of the upper surfaces of the wings. In some cases, however, I may form the two surfaces by building up on an imaginary surface traced by a straight line as above described, both surfaces approaching closely to the imaginary directing surface so formed.

In all the above described machines steering may be effected by flaps at the tips of the wings turned about pivots in the required direction. For instance if it is desired to make the front of the machine rise, the rear tips of the wings

would be inclined upwards. In order to turn to the right, the right hand wing tip would be raised, and the left hand wing tip lowered; and in order to turn to the left, the right hand wing tip would be lowered, and the left hand wing tip raised, while to make the machine descend, the rear wing tips would be inclined downwards.

The above described forms of wings are applicable to machines in which two sets of wings are superposed, as well as to the monoplane type of machine above described.

Dated this 3rd day of April, 1909.

MARKS & CLERK,
18, Southampton Buildings, London, W.C.,
13, Temple Street, Birmingham, and
30, Cross Street, Manchester,
Agents.

COMPLETE SPECIFICATION.

Improvements relating to Aeroplanes.

I, JOHN WILLIAM DUNNE, Gentleman, of 16, Charing Cross, London, W.C., do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

The object of the present invention is to obtain a form of aeroplane which by virtue solely of the arrangement and form of its supporting surfaces possesses when properly ballasted automatic stability in still air, and also, without requiring any alteration of its centre of gravity or of its surfaces, in very high winds; further, to construct the aeroplane in such a manner that it possesses in calm and in agitated air a large measure of freedom from oscillation, a quality quite distinct from that of stable equilibrium, and also to obtain large pressure reactions when the aeroplane is driven at an angle against the air.

The invention consists in constructing each of the main supporting surfaces as a rearwardly projecting rigid wing, the angle of incidence of which decreases from the centre towards the tips and in some cases changes sign and compensating for the decreased lifting power of the tips by shaping the wing so as to compress air between a positively inclined portion of the wing near the centre and a negatively inclined portion in the region of the tip.

The invention also consists in constructing each of the main supporting surfaces as a rearwardly projecting wing, the upper face of which may be defined as traced by a straight line travelling on two guide curves one of which may be infinitely small, so arranged that the resulting surface swept out is convex towards its upper side in all sections taken fore and aft and laterally, the angle of incidence gradually decreasing from the centre to the ends of the wings and in some cases changing sign, and the lower faces of the wings being preferably concave.

It will be understood that in the present specification, where not otherwise specified, the surfaces of the wings referred to are the upper surfaces, the lower surfaces being preferably concave, although plane or even convex portions may occur where such are advisable by reason of considerations such as the strength of the structure. It will also be understood that the expression "angle of incidence" in the fore and aft direction means in the case of a plane surface the angle made by the fore and aft section of that surface with the line of flight;

in the case of a curved surface the angle made by the line of flight with a straight line drawn from front end to rear end of the curve exposed by a cross section.

The invention more specifically consists in forming the upper faces of the rearwardly projecting main supporting wings or the outer portions thereof as portions of the surfaces of cones or cylinders, the angle of incidence of said wings decreasing towards the tips, and in some cases changing sign.

The invention also consists in a form of aeroplane in which the main supporting surfaces are in the form of rearwardly projecting wings, the wings or the outer portions thereof forming parts of the surfaces of cones whose apices are towards or outside the rear ends of the wings.

The invention also consists in the improved constructions of aeroplane hereinafter described.

In order to obtain large pressure reactions when the aeroplane is driven at an angle against the air the lifting surfaces must be convex on the upper side and preferably concave on the under side. Further, the machine should be supported by either a single pair of main wings, one wing on each side, or by two such systems placed one above the other as the addition of any further surfaces tends to reduce the efficiency of the whole.

In order to maintain fore and aft stability, I have found it advisable that the whole or the outer part of each wing should have its leading edge so sloped backwards and outwards that the tips of the wings come behind the centre of gravity of the apparatus.

I find that in plan the angle of inclination of the wings to the line of flight should be between the limits of 40° and 70°.

In order to render the machine free from oscillation, it is advisable that as the wing extends outwards the angle of incidence should decrease gradually so that there may be no abrupt alteration of angle at any part of the wing. With a wing so formed alterations of the mean angle of incidence bring into play gradual alterations in the pressures on the wings gently to correct the deviation from normal conditions. It is of the greatest importance that this correction should be gentle at the commencement of an oscillation, and it is equally important that the tendency should persist through wide ranges of variation in the mean angle of incidence and increase as the departure from the normal conditions increases. This latter condition requires that the difference between the angles of incidence of the inner and outer portions of the wing should be considerable, a condition which in turn requires in general a negative angle of incidence at the tips under normal flight conditions.

I have found that twisting the wings or rendering them flexible so that they twist under air pressure, to cause the tips to present the requisite small angle, involves the disadvantage that sections taken fore and aft across the tips of the wings or from the inner portion to the tip gives curves more or less concave on their upper sides, thus greatly detracting from the lifting powers of the wing. A twisted wing therefore is unable to give large pressure reaction when driven at an angle against the air. I have found further that when such a twisted wing changes its mean angle of incidence the changes thereby brought about in the pressures on the outer portions which are concave on their upper sides, occur far too abruptly for steadiness, and in very high winds may produce a condition of unstable equilibrium. Also that the similar concavity on the lateral cross section of the wings gives lateral instability in disturbed air. This form of wing therefore is not suitable.

In order to obtain the correct form therefore it is necessary to consider,

Firstly, how the angle of the fore and aft sections can be made gradually to decrease as the wing is built outwards without producing points of inflexion in the surfaces; and

Secondly, how considerable differences in the angles of the inner and outer

portions can be maintained without too much loss of pressure under the outer portions and therefore loss of lifting power.

I will now describe certain forms of wing surface by way of example which meet the conditions laid down above and will then describe a complete aeroplane in which one such wing form is embodied.

Referring for this purpose to the accompanying drawings which form part of the specification:—

Figure 1 shows a plan of a form of wing in which the upper face forms part of a conical surface with rearwardly disposed apex,

Figure 2 being a corresponding side elevation.

Figure 3 shows a plan of another modification in which the upper face of the wing forms part of a conical surface with forwardly disposed apex,

Figures 4 and 5 being corresponding rear view and side elevations.

Figure 6 shows a plan of a modified form of wing in which the upper face is composed of parts of two conical surfaces with reversely disposed apices.

Figure 7 being a corresponding side elevation.

Figure 8 shows a plan of another modification of wing in which the upper face is composed partly of a conical surface with a forwardly disposed apex and partly of a cylindrical surface,

Figures 9 and 10 being corresponding rear and side elevations respectively; while

Figure 11 shows a plan of a modification in which the upper face of the wing forms part of a cylindrical surface,

Figure 12 being a corresponding side elevation.

In the above plan views the left hand wing only is shown for simplicity in each case, the right hand wing being understood to be similar and symmetrically situated with regard thereto on the other side of the centre line, the position of which is indicated by the arrow; the arrow likewise shows the direction of flight.

Moreover, those parts of the wing outline which are hidden are dotted in the figures while such parts of the guide curves as do not coincide with the wing outline are indicated by dot-and-dash lines.

Finally, Figure 13 shows a plan of a monoplane in which is embodied the wing form of Figure 1,

Figures 14 and 15 being corresponding side and front elevations; while

Figure 16 shows a perspective view of the frame supporting the propellers.

It will be understood that the drawings are to a certain extent of a diagrammatic nature while the same reference symbols are used when possible to denote corresponding parts in the different figures.

In carrying the invention into effect according to one form (see Figures 1 and 2), the upper wing surface is swept out by the straight line X_1 Y_1, which always passes through the rearwardly situated point X_1, and travels along the guide curve, E C, so that it takes up the various positions, X Y_2, X Y_3, X Y_4, and so on until it reaches the position, X Y_{12}. It is evident that the surface so swept out is a portion of that of a cone and therefore only one guide curve is necessary for its construction. The second guide curve referred to above may either be considered as infinitely small and situated at X_1, or it may for facility in construction be the curve exposed by any convenient section taken through the cone surface formed by the line, X_1 Y_1.

It will be seen on reference to Figure 2 that the principal guide curve, E C, is straight between the points, F and D, so that the portion of the wing surface enclosed within the figure, A H D G, (Figure 1) is a plane.

For the sake of clearness in this part of the description the wing may be considered to have no thickness so that the straight line, X_1 Y_1, sweeps out at the same time a wing surface which is concave below and convex above.

Further, by selecting that portion of the conical surface so generated indicated by the parallelogram, A B C D, the angles of incidence of the fore and aft

section of such wing gradually become less and change sign as the wing is built outward.

It will be evident therefore that this form of wing fulfils one of the necessary conditions of the problem.

Again, when a wing of the form described is driven against the air at a small mean angle of incidence, the air owing to the larger angle of incidence of the inner and forward portions of the wing is driven slightly outwards as well as downwards, thus transmitting pressure across the underside of the wing on to the down-turned under surface of the negatively inclined tips and so compensating to a considerable extent for the imperfect air supply from the normal front direction due to the small or negative angle of inclination.

Again, it will be seen that the whole of the under surface of the wing may be considered as formed of a number of straight channels converging towards the apex of the cone or as comprising a portion of the inner surface of a pipe which gradually narrows towards that point. There is a tendency therefore not only to force the air outwards along these channels or pipes but also to compress it thereby increasing the pressure under the outer portions, and thus adding further to the lift under these portions. The feed of air from the inner or forward portions towards the outer portions and the compression of air under the outer portions enables the outer portions to be placed at a very considerable negative angle of incidence as compared with the inner portions without incurring serious loss of lifting power.

Such a form of wing therefore completely solves the problem, and is the form which I prefer to use.

According to a modified form of the invention (see Figures 3, 4 and 5), the tracing line is pivoted at the forwardly disposed point, A, and travels on the guide curve, E D, taking up the successive positions, A X_1, A X_2, A X_3, and so on to A X_{11}, thereby forming a cone-shaped surface. The second guide curve may in this case be considered as that exposed by a section through the line, F G, for example.

In this form lifting power is sacrificed to a certain extent to increased steadiness.

Further, between the two forms of the invention above described, intermediate forms may be employed in which the generating line on the whole moves more nearly parallel to itself, such intermediate forms permitting different degrees of stability and lifting power to be obtained.

Thus, referring to Figures 6 and 7, it will be seen that the outline of the wing in plan and the guide curve, E C, are the same as in Figure 1. The line, X_1 Y_1, travels as in Figure 1 until it reaches the position, X Y_5, but then pivots about the point, A, and the X end of the line moves forward so that the line travels on the remainder of the guide curve, F C, taking up the successive positions, A X_2, A X_3, A X_4, and so on to A X_9. The wing surface thus formed consists of two cone-shaped surfaces merging into each other, one having its apex rearwardly disposed at X_1, and the other having its apex oppositely disposed in a forward direction at A, but it will be seen that the nature of the guide curve and of the travel of the line is carefully adjusted so that no inflexion of the wing surface takes place at the junction of the two cone-shaped surfaces. The nature of the surface produced is very similar to that seen in Figure 2, with the main difference, however, that the front edge is now straight.

The curve exposed by any convenient section through the surface may for facility in construction be utilised as the second guide curve.

I consider that this type of wing gives much greater steadiness in flight than that shown in Figures 1 and 2, but that its efficiency is less.

Again, Figures 8, 9 and 10, show another modification of wing surface, partly conical and partly cylindrical.

The front part of the wing is formed as in Figure 6, as although a different guide curve, E B, is used, the part of this curve, E G, used in describing the

surface between A C and A D is merely that exposed by a cross section taken in a similar direction through the wing shown in Figure 6. The guide curve, however, is then straight as far as the point, H, whence it curves downward to B and over this portion of the curve the line travels parallel to itself forming a portion of the surface of a cylinder. Two guide curves are evidently necessary for the tracing out of this part of the wing surface, and the second guide curve is indicated by J K, the portion, L K, being a facsimile of the curve, H B.

In plan the wing is the same shape as already described with reference to Figures 1 and 6.

This form of wing as will be explained hereinafter is well adapted for biplane construction.

Finally, in the wing shown in Figures 11 and 12, the apex or apices of the cone or cones of which this wing forms part of the surface or surfaces is or are removed to an infinite distance either in the direction, X_1, or in the direction, Y_1, so that the wing really forms part of the surface of a cylinder. The guide curves are indicated by F B and C E.

A convenience which results from a wing of this form is that if the guide curves, F B and C E, be made arcs of circles of equal radius the curves exposed by any number of parallel planes intersecting the wing through both front and back edges are equal and similar. This enables the builder to use one or two fixed patterns of rib throughout, instead of having to construct every rib in the wing to a different curve as in the foregoing examples and consequently the cost of construction is less. This form of wing gives good stability but requires driving at a high speed to obtain adequate lift.

It will be understood that the wings in plan may take other forms than the parallelograms and triangle shown above by way of example.

In the above description of different wing forms I have considered the supporting surfaces to be of negligible thickness, but it will be evident that in actual practice a certain thickness of the wings is necessary. The most important consideration, however, is the smoothness and form of the upper surface, as it is on the perfection of this part that the steadiness of the machine in flight largely depends.

In constructing the wings in practice, the lower surface is preferably swept out in a similar manner to the upper surface. The positions of the cone apices, however, are different, as otherwise the edges of the under surface would not approximate to those of the upper surface. In a double surface wing, therefore, I prefer to trace the upper surface as above described, and to describe the lower surface in a similar fashion, the path of the travelling line forming the lower surface being so chosen that the front and rear edges come as close as possible to those of the upper surface. One or both the surfaces is or are then eased off, until the edges are made to correspond, the alterations being so made that smoothness and regularity are preserved as much as possible.

It may however, be advisable in some cases to subordinate the regular coning of the under surface to considerations of the best position for the thicker parts of the wing. In constructing a machine on this principle, the upper surface would be properly swept out by the straight line, as above described, while the lower would simply lie along the bottom of properly shaped ribs.

In other cases, I may form the two surfaces by building up on an imaginary surface traced by a straight line as above described, both surfaces approaching closely to the imaginary directing surface so formed.

It will be seen, however, that if the under surface of the wing is swept out by a straight line in the manner indicated above, and the wing is of only moderate thickness the upper surface would depart to only an immaterial extent from the true geometrical form.

I will now describe one form of monoplane by way of example fitted with the type of wing described above with reference to Figures 1 and 2.

Referring for this purpose to Figures 13 to 16, the body, 1, is shaped like a bird, fish or boat and carries a motor, pilot, stores and part of the mechanism driving the propellers, 2. This body is preferably rectangular in cross sections taken through those portions which lie behind the wings, 3, the lower front part or "breast" being concave and shaped on each side as an extension of the underside of the cone-shaped wing surface (see Figure 14).

The tips of the wings should extend behind the centre of gravity of the whole apparatus, this point being distant from the front end at about two-fifths of the length of the body, while the rear end of the body should preferably be lower than the rear tips of the wings.

The body, 1, should be strongly constructed in the forward and middle part where the load is carried and lightly constructed in the rear part. The sides of the body are raised above the stronger portion of its framework by light bulwarks, 4, and the upper part is covered in preferably by light fabric stretched across level with the tops of the bulwarks, 4, a space, 5, being left for the pilot. A single strong skid or runner, 6, lies in a fore-and-aft direction under the centre of the body, 1, and is attached thereto by a single rigid member, 7, and by symmetrically disposed pairs of rigid members, 8, sloping upwards and outwards from the skid, 6, to the strongly built sides of the body, 1. A pair of wheels, 9, set side by side and directly under the strong sides of the body are attached to the skid, 6, or to the apices of horizontal triangular frames projecting therefrom and are further connected to the strong sides of the body by forked vertical members, 10.

The wings, 3, are attached to the body, 1, by strong boom members, 11, which members are preferably of "**I**" section or of girder-like construction and are curved to fit under the cone-shaped wing surface but may be enclosed in the thickness of the wings. Cross ribs, 12, curved to fit the wing surface serve to strengthen the wings, 3, and to preserve their shape. Vertical struts, 13, are attached to the boom members, 11, projecting above and below and connected at their upper and lower ends by fore-and-aft members, 14, the whole being cross-braced above and below by wires, 15.

A frame is erected upon the strong sides of the front part of the body, 1, consisting of an upright strut, 16, a double strut shaped like an inverted **V**, 17, and a fore-and-aft solid member, 18, the whole frame being braced with wires, 19. Wires, 20, are connected from the outer ends of the boom members, 11, to the tops of the struts, 13, and thence to the tops of the struts, 16 and 17, and wires, 21, pass also from the outer ends of the boom members, 11, to the lower ends of the struts, 13, and thence to the skid, 6. Other wires, 22 and 22ª, pass from the intersections of the struts, 13, with the boom members, 11, to the tops of the struts, 16 and 17, and to the skid, 6.

For the guidance of all machines constructed in accordance with this specification, I consider that the controls described in the Patent Specification, No. 1469 of May 21st, 1870, which comprise horizontally pivoted flaps at the rear tips of the wings, are particularly suitable. In the present invention, similar flaps or ailerons, 23, are hinged by their front edges to the outer parts of the rear booms, 11. If with such flaps it is desired to incline the front of the machine upward the flaps would be inclined upwards so as to receive air pressure upon their upper surfaces and so force the rear of the machine down. To incline the front of the machine downward the flaps would be lowered so as to receive air pressures on their under sides and so lift the rear of the machine. In order to turn to the right, the right hand flap would be raised and the left hand flap lowered; and in order to turn to the left, the left hand flap would be raised and the right hand flap lowered.

It will be observed that that portion of the rear boom, 11, which is opposite the flap, 23, is part straight and part with a slight curve. In order to simplify the hinging of the flap, 23, to the boom, 11, I slightly modify the surface at the extreme rear tip of the wing, without materially reducing its concavity, so that

that part of the rear boom, 11, which is opposite to the flap, 23, may be made straight throughout, as this can be effected without departing from the general characteristics of the wing.

This modification I may effect where necessary in all wings constructed in accordance with the present invention.

Short vertical struts, 24, intersect and are attached to the solid front edges of the flaps, 23, and their upper and lower ends are attached to the rear corners of the flaps, 23, by wires, 25. Stranded wire cords, 26, are attached to the ends of the struts, 24, and are led round a guide, 26a, and thence by any convenient arrangement of pulleys or Bowden sheaths to the pilot. By pulling and slacking on these cords the flaps, 23, can be raised or lowered.

The motor, 27, is preferably placed in front of the pilot and the propellers behind, the latter in this position having less effect on the stability of the machine. A shaft, 28, passing under the pilot's seat low down in the body, 1, transmits the power from the motor to the propellers, 2, which are attached to the laterally projecting frame, 29, (see Figure 16) and are driven from the shaft, 28, by chains, belts or by any convenient mechanism.

The shaft, 28, is preferably set below the level of the crank case of the motor and driven therefrom by any convenient gearing; by extending the shaft forward under the motor, the position of the latter can be readily changed forwards or backwards without any further disturbance of the driving mechanism beyond that involved in shifting the sprocket wheel or toothed wheel at the forward end of the shaft, 28, forwards or backwards to correspond.

Any of the above forms of wing are applicable to machines in which two sets of wings are superposed as well as to the monoplane type of machine above described.

Of the forms described above, however, I consider that shown in Figures 8, 9 and 10 the most suitable for this purpose, since on account of the whole of the front edge being straight and nearly all the back part being flat, straight boom members can be utilised in the construction of the wings and thus two such wings can be readily held in position one above the other by a truss system of upright struts and diagonal ties as in ordinary biplane construction.

I have found by practical experiment that machines as described supported mainly by wings of which the whole or the outer portions are inclined backward and constitute portions of the surfaces of cones or cylinders fully satisfy the conditions of stable and steady flight.

Finally, I wish it to be understood that although I have described certain specific form of wing and in addition a complete monoplane machine in considerable detail, nevertheless I do not intend the scope of my invention to be thereby restricted as it will be evident that the principles above enunciated and explained may be embodied in practice in a variety of different forms.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:—

1. In aeroplanes, constructing each of the main supporting surfaces as a rearwardly projecting rigid wing, the angle of incidence of which decreases from the centre towards the tips and in some cases changes sign and compensating for the decreased lifting power of the tips by shaping the wing so as to compress air between a positively inclined portion of the wing near the centre and a negatively inclined portion in the region of the tips, substantially as and for the purpose described.

2. In aeroplanes, constructing each of the main supporting surfaces as a rearwardly projecting wing the upper face of which may be defined as traced by a straight line travelling on two guide curves, one of which may be infinitely small, such guide curves being so arranged that the resulting surface swept out is convex towards its upper side in all sections taken fore and aft and

laterally, the angle of incidence gradually decreasing from the centre to the ends of the wings and in some cases changing sign, substantially as and for the purpose described.

3. In aeroplanes, forming the upper faces of the rearwardly projecting main supporting wings or the outer portions thereof as portions of the surfaces of cones or cylinders, the angle of incidence of said wings decreasing towards the tips and in some cases changing sign, substantially as and for the purpose described.

4. In aeroplanes, constructing each of the main supporting surfaces in the form of rearwardly projecting wings, the wings or the outer portions thereof forming parts of the surfaces of cones whose apices are towards or outside the rear ends of the wings, substantially as and for the purpose described.

5. Aeroplane supporting wings embodying the principles hereinbefore set forth and substantially as described with reference to the accompanying drawings.

6. Improved aeroplanes substantially as hereinbefore described or indicated with reference to the accompanying drawings.

Dated this 4th day of October, 1909.

MARKS & CLERK,
57 & 58, Lincoln's Inn Fields, London, W.C.,
13, Temple Street, Birmingham, and
25, Market Street, Manchester,
Agents.

Redhill: Printed for His Majesty's Stationery Office, by Love & Malcomson, Ltd.—1910.

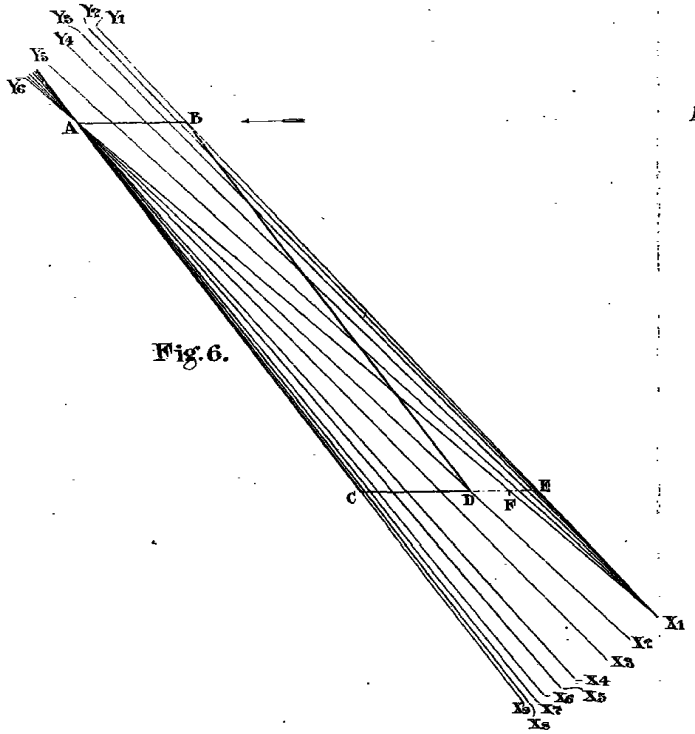


Fig. 6.

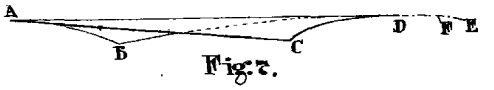


Fig. 7.

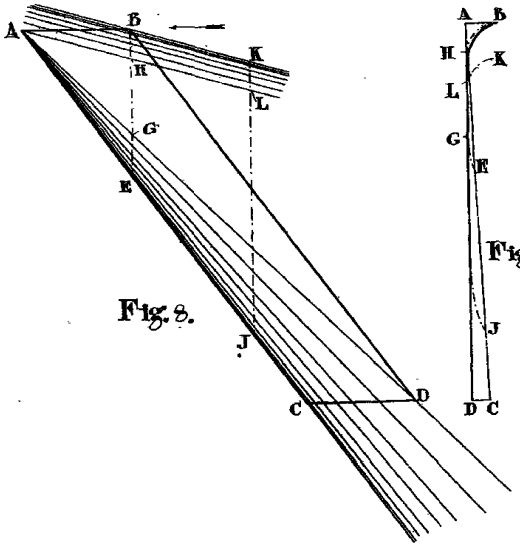


Fig. 8.

Fig. 9.

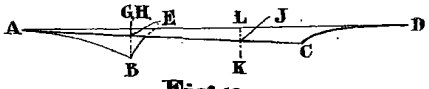


Fig. 10.

Malby & Sons Photo Litho

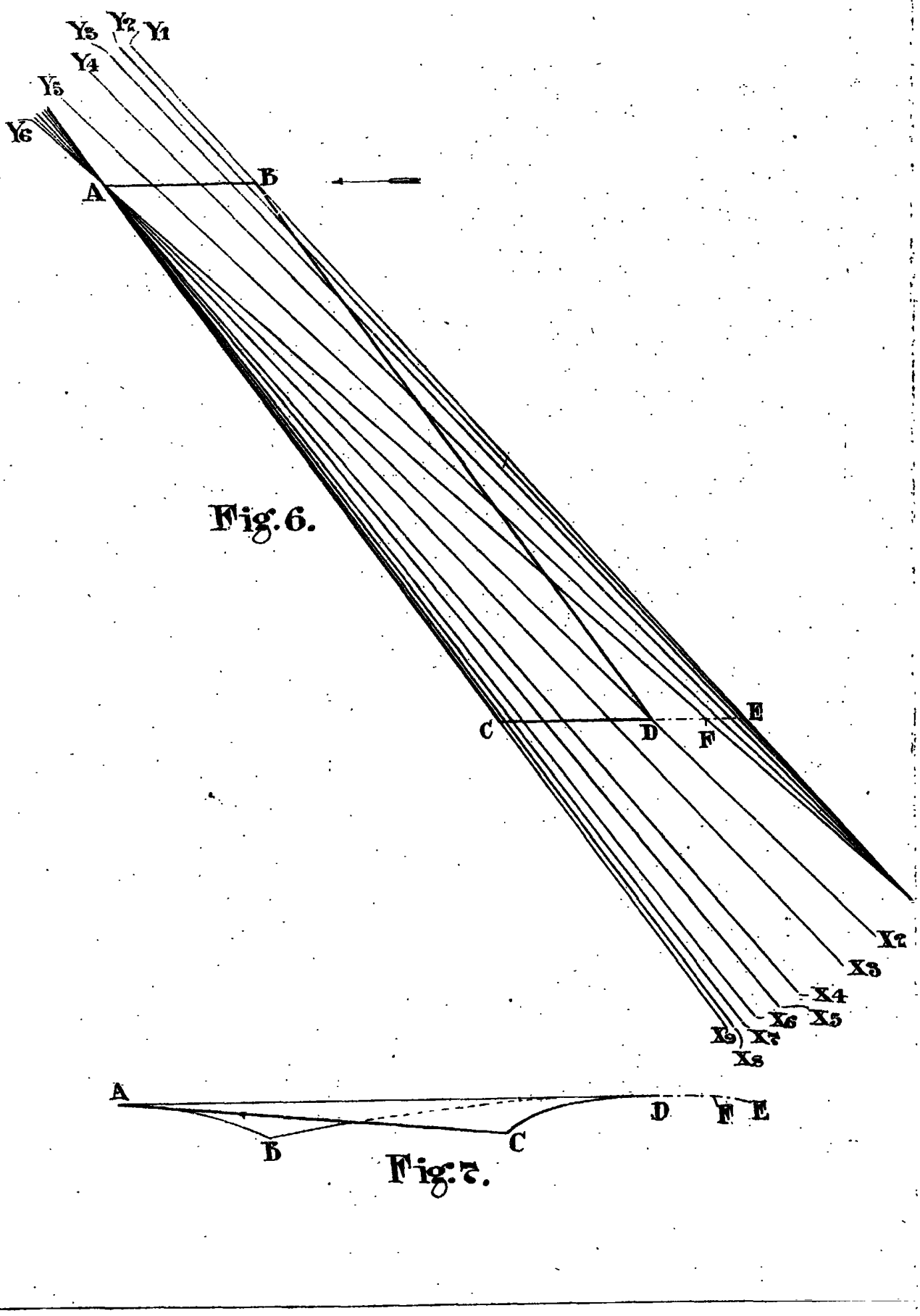


Fig. 6.

Fig. 7.

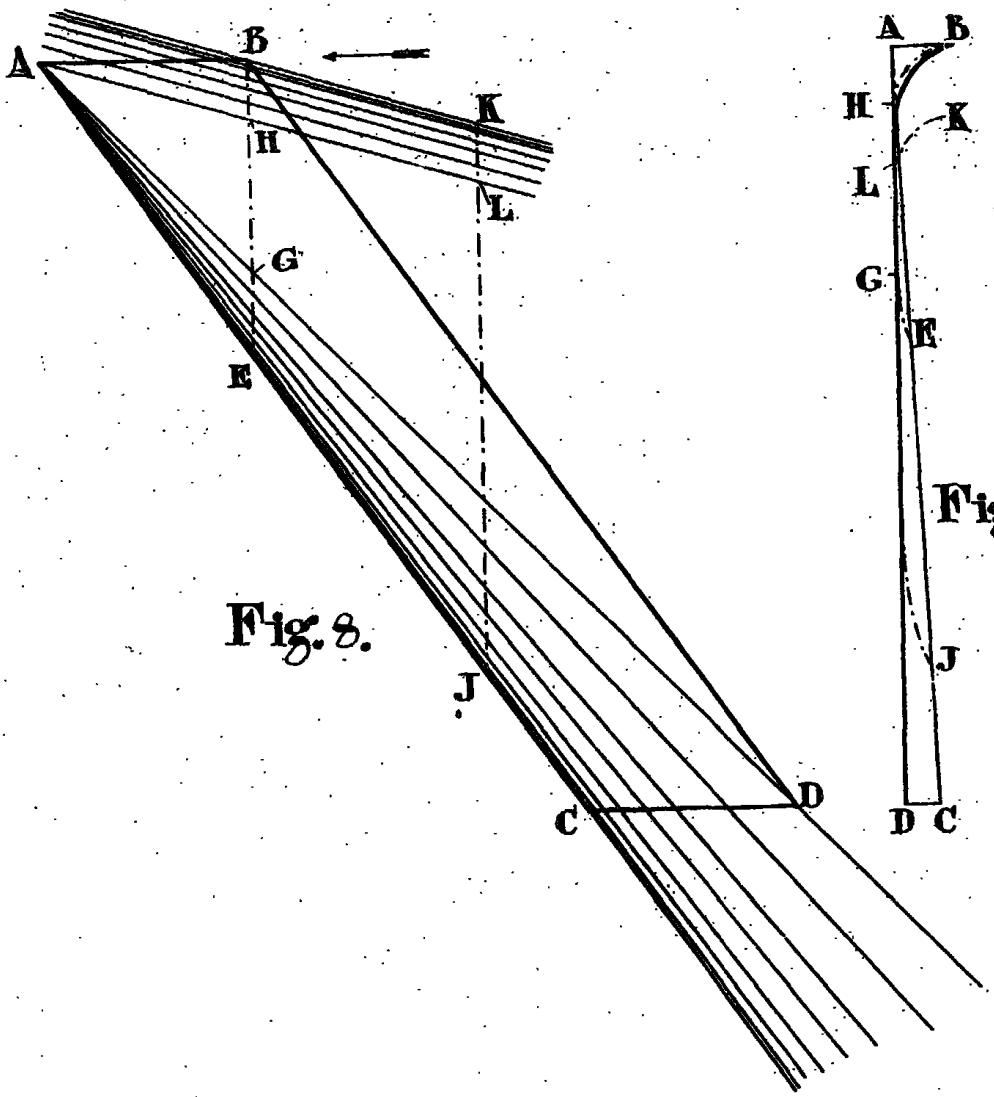


Fig. 8.

Fig. 9.

X1

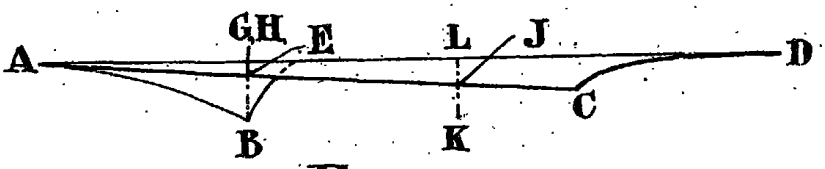


Fig. 10.

Malby & Sons, Photo-Litho.

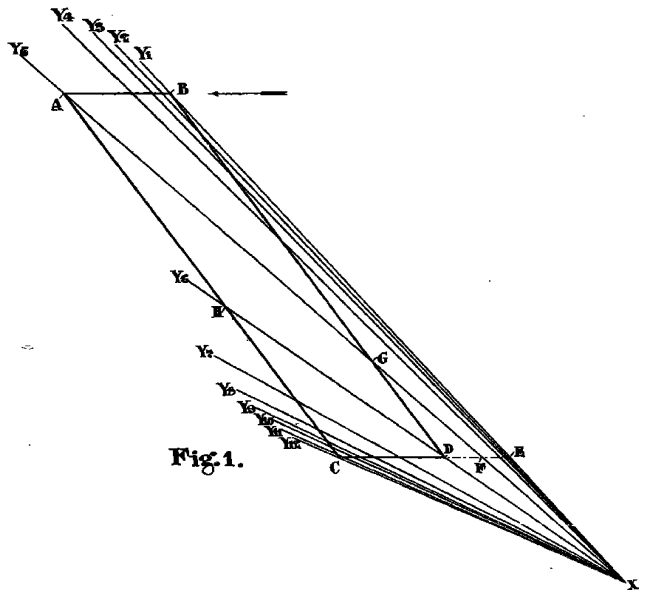


Fig. 1.

Fig. 2.

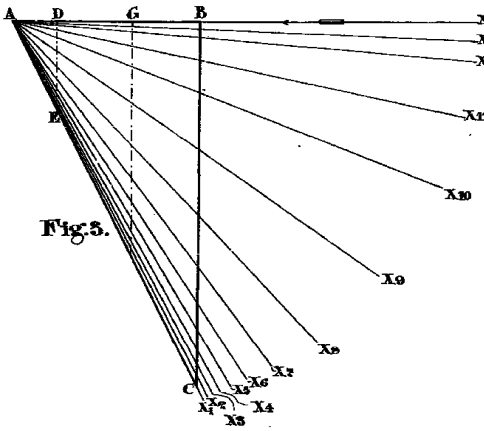


Fig. 3.

Fig. 4.

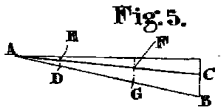


Fig. 5.

Malby&Sons Photo-Litho

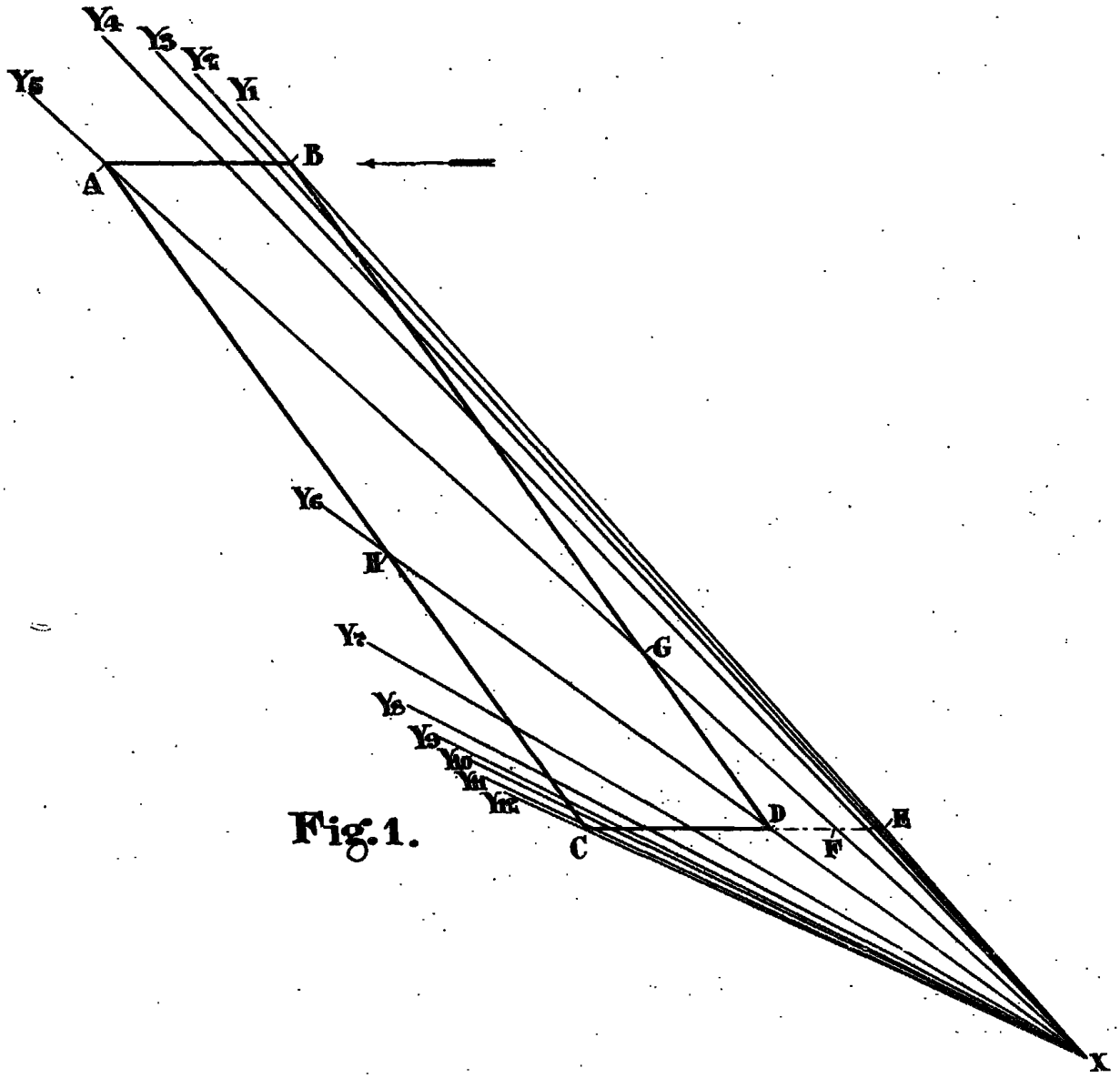


Fig. 1.

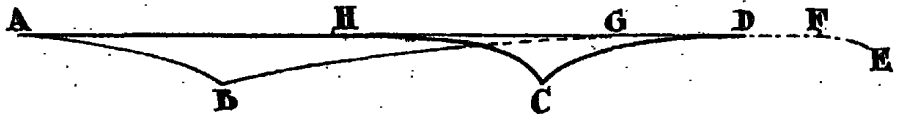


Fig. 2.

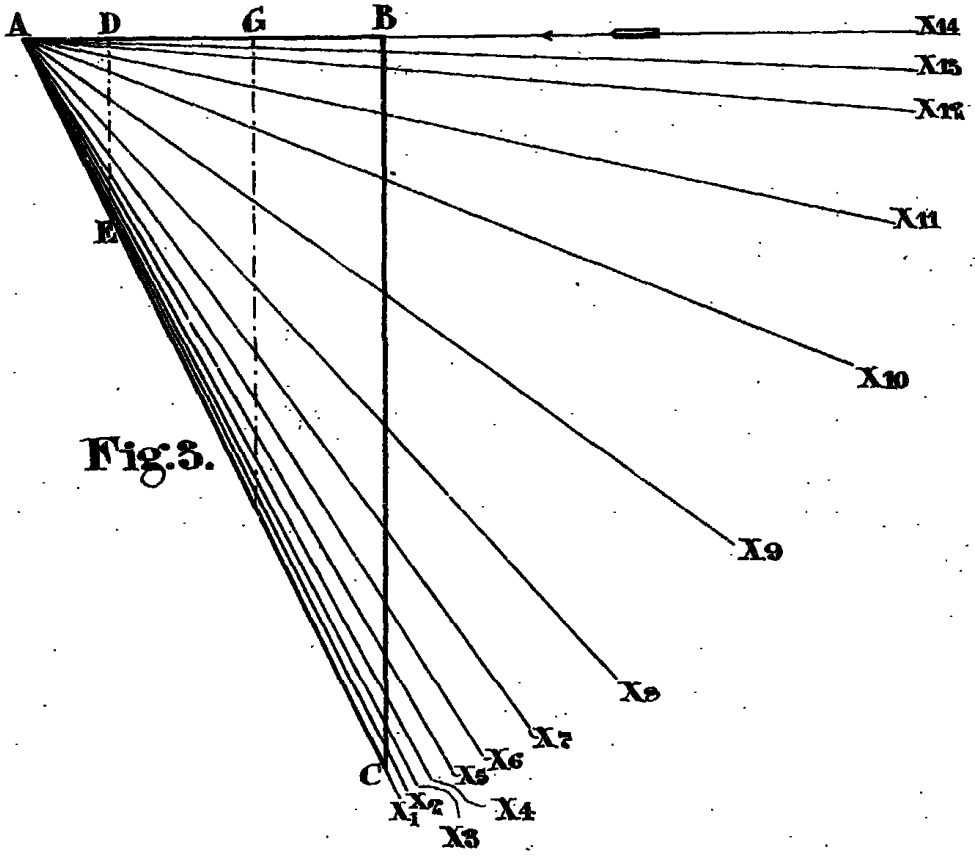
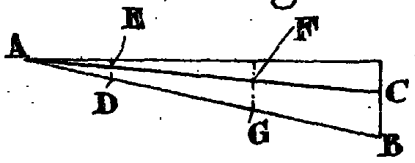


Fig. 3.

Fig. 4.

Fig. 5.



Malby&Sons, Photo-Litho.

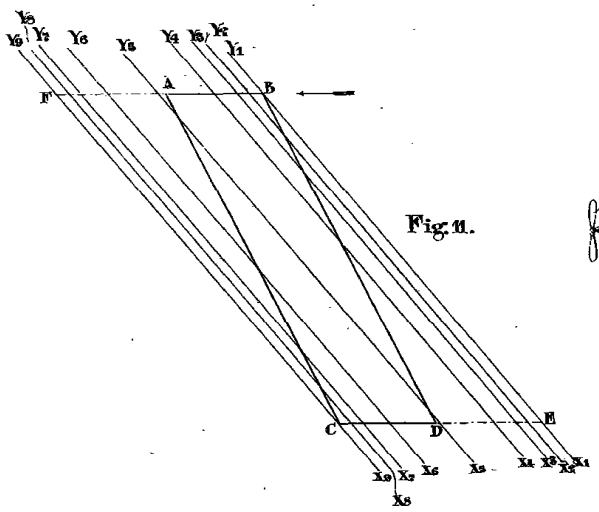


Fig. 11.

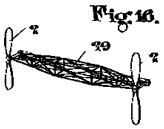


Fig. 16.

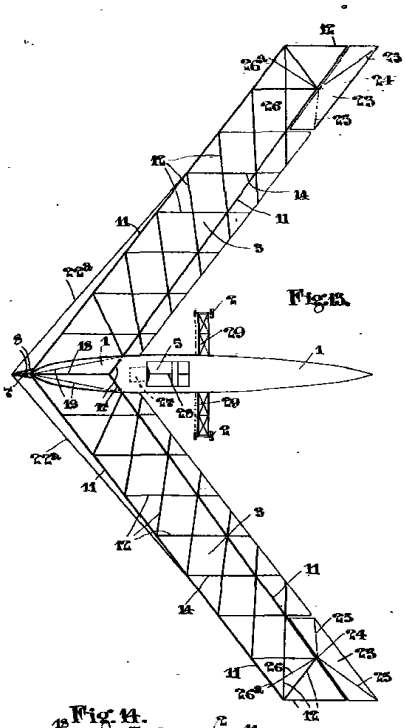


Fig. 13.

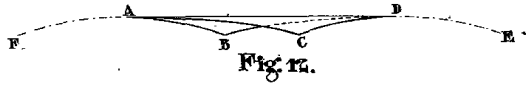


Fig. 12.

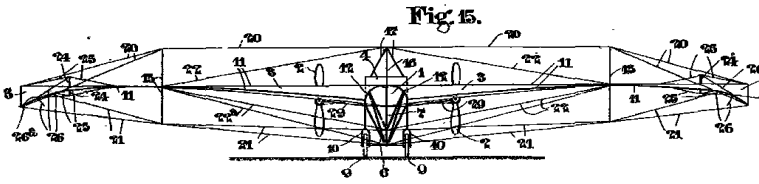


Fig. 15.

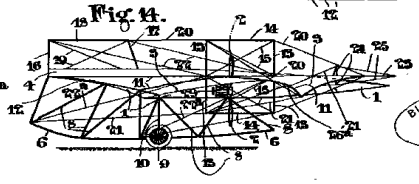


Fig. 14.

Malby&Sons, Photo-Litho

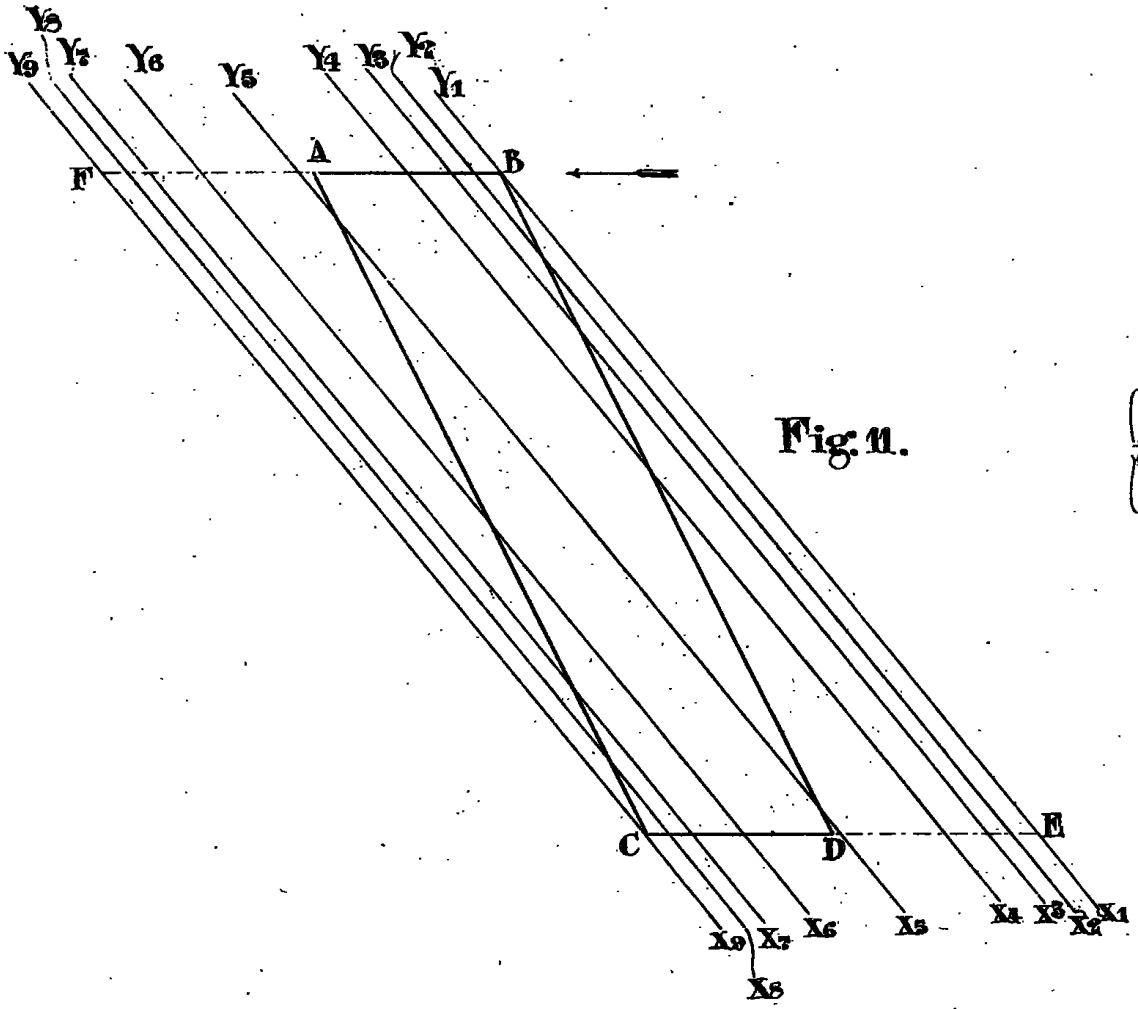


Fig. 11.

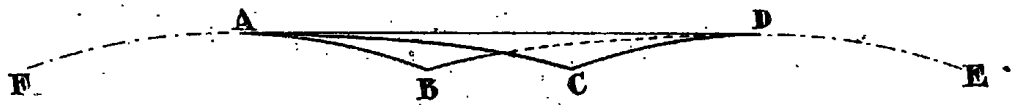
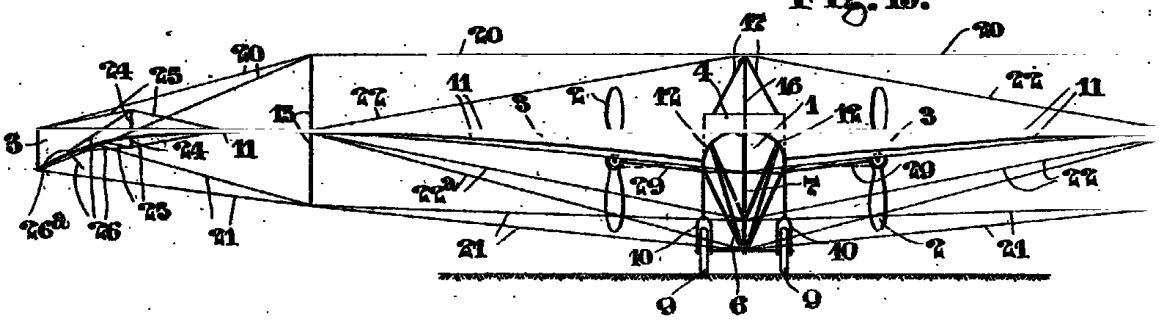


Fig. 12.

Fig. 15.



(3 SHEETS)
SHEET 3.

Fig. 16.

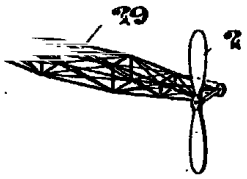


Fig. 13.

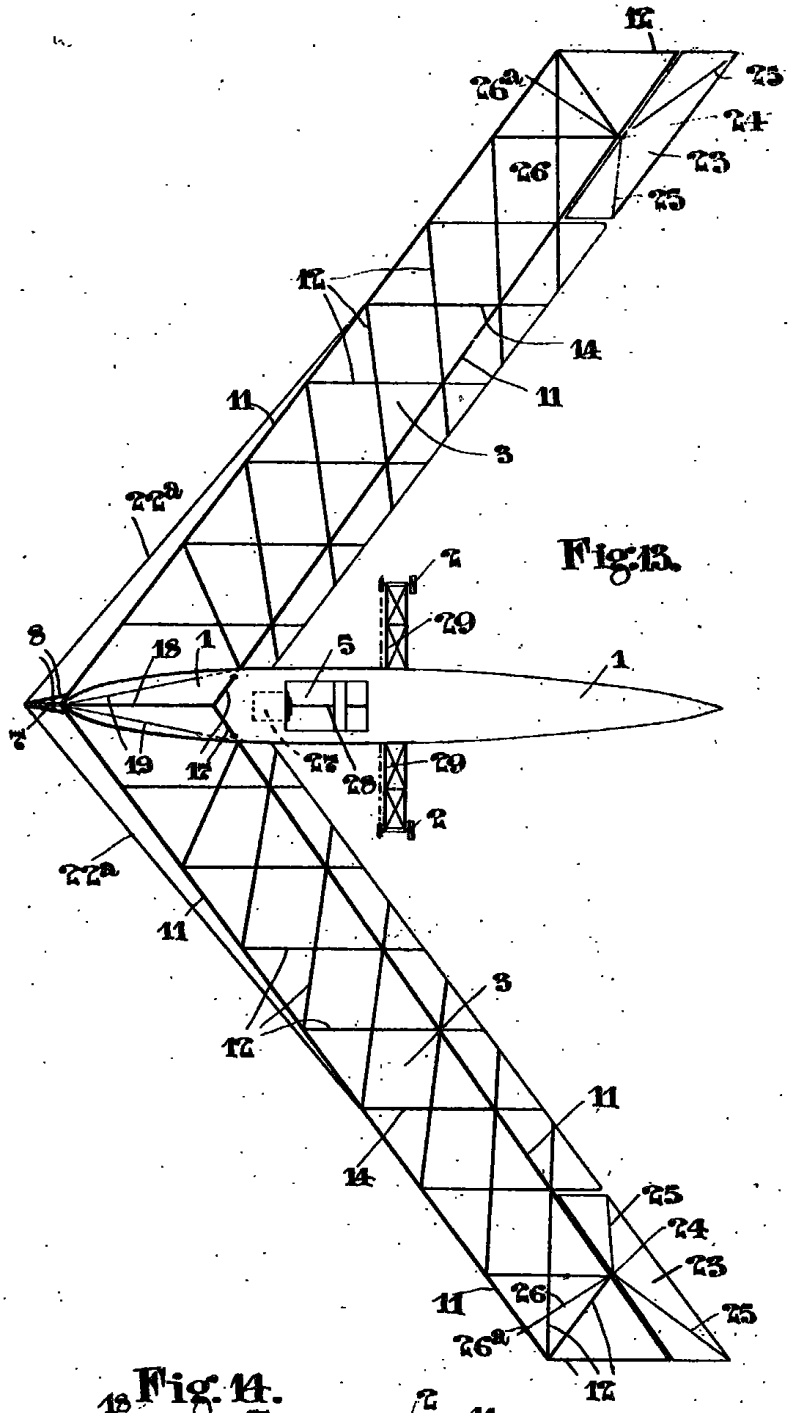
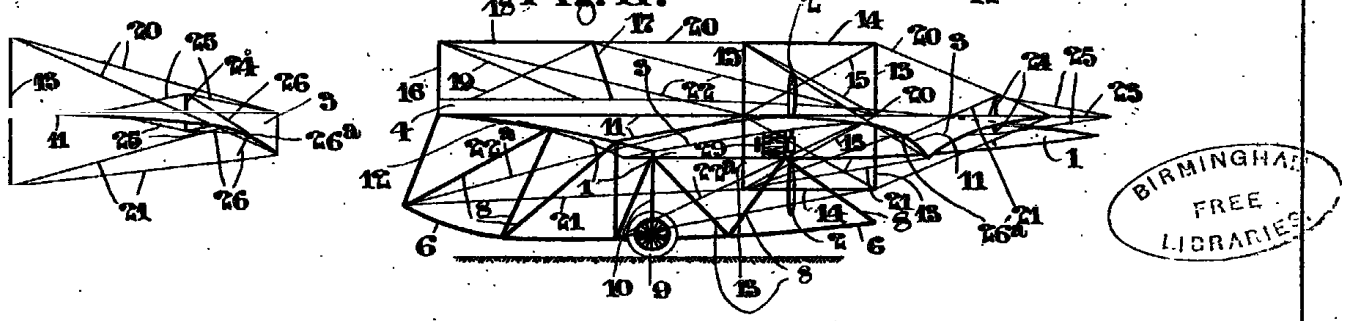


Fig. 14.



Malby&Sons, Photo-Litho.