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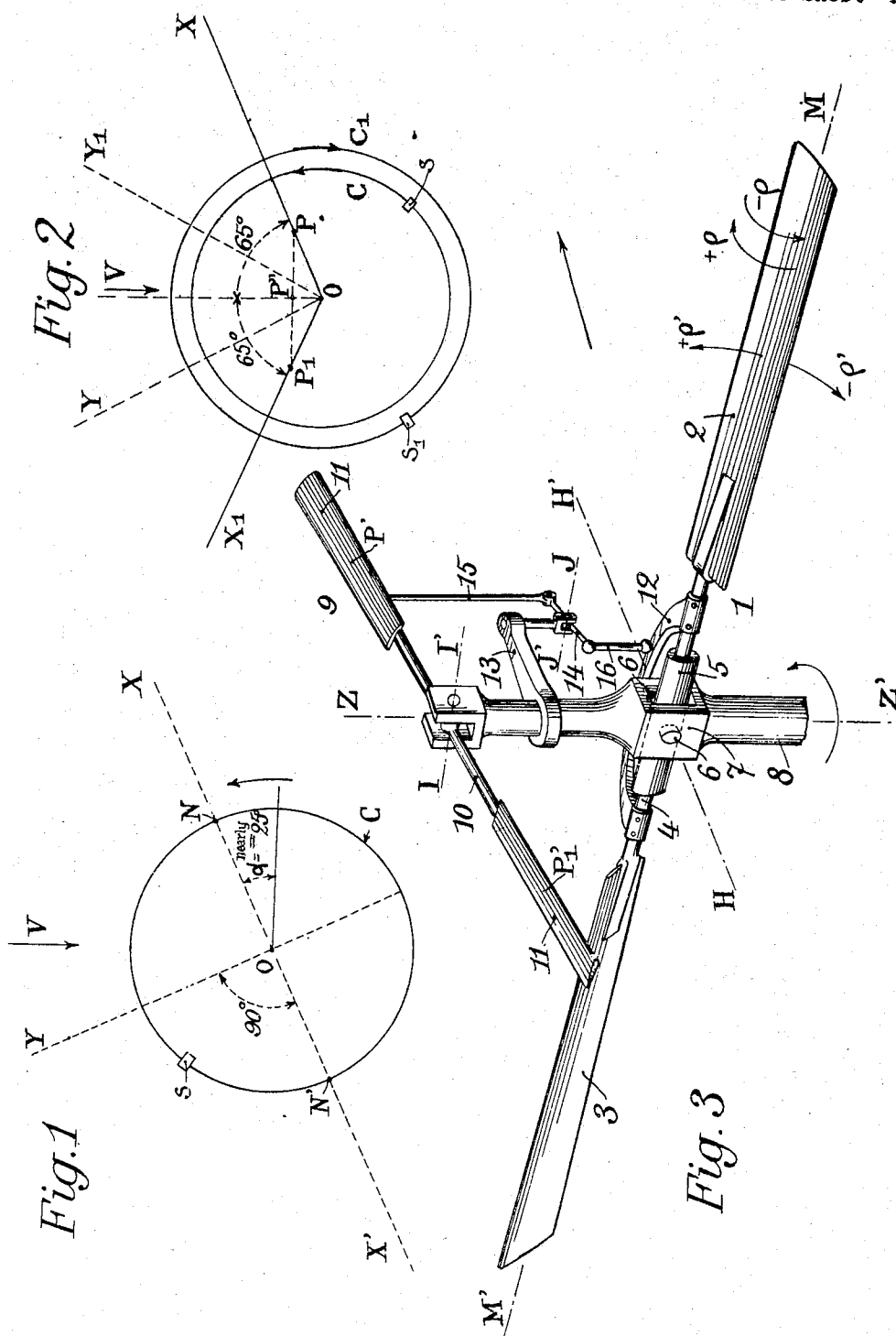
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1,800,470

SUSTAINING DEVICE WITH REGULATORS

Filed June 13, 1927

4 Sheets-Sheet 1



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4 Sheets-Sheet 2

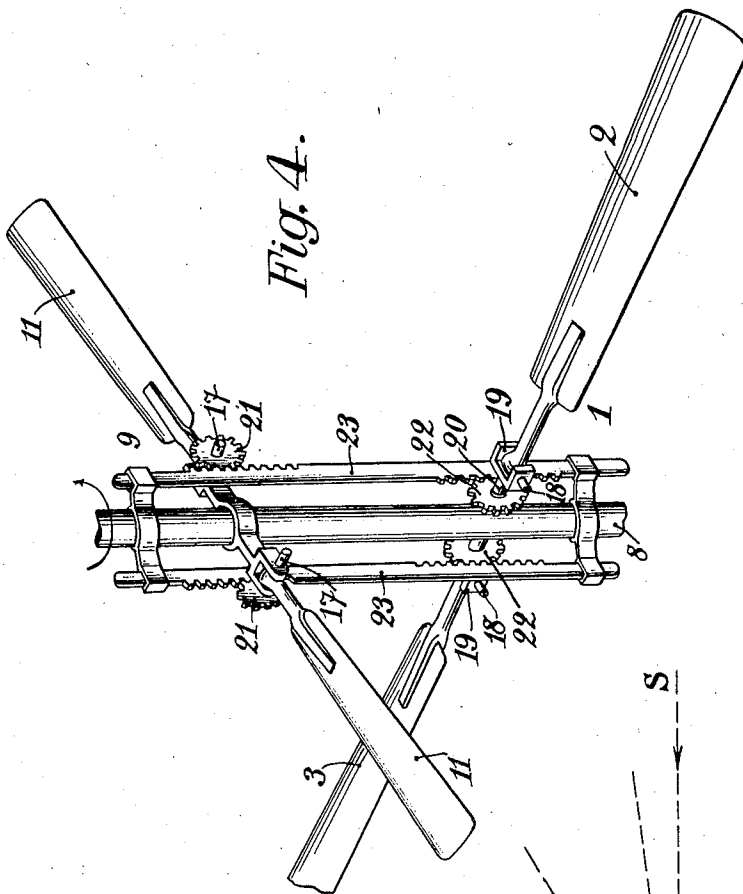


Fig. 4.

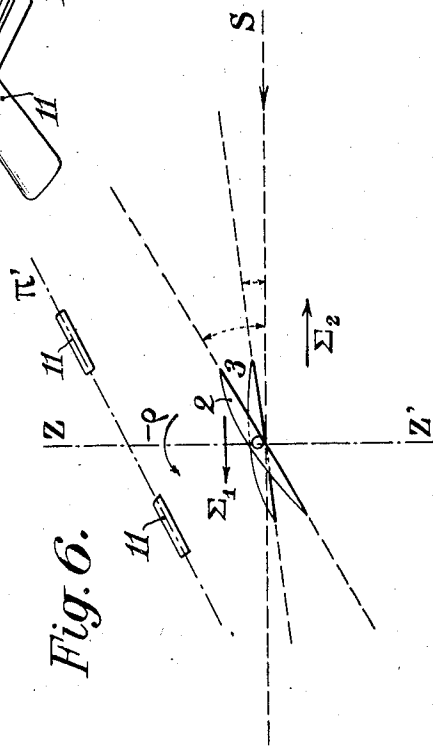


Fig. 6.

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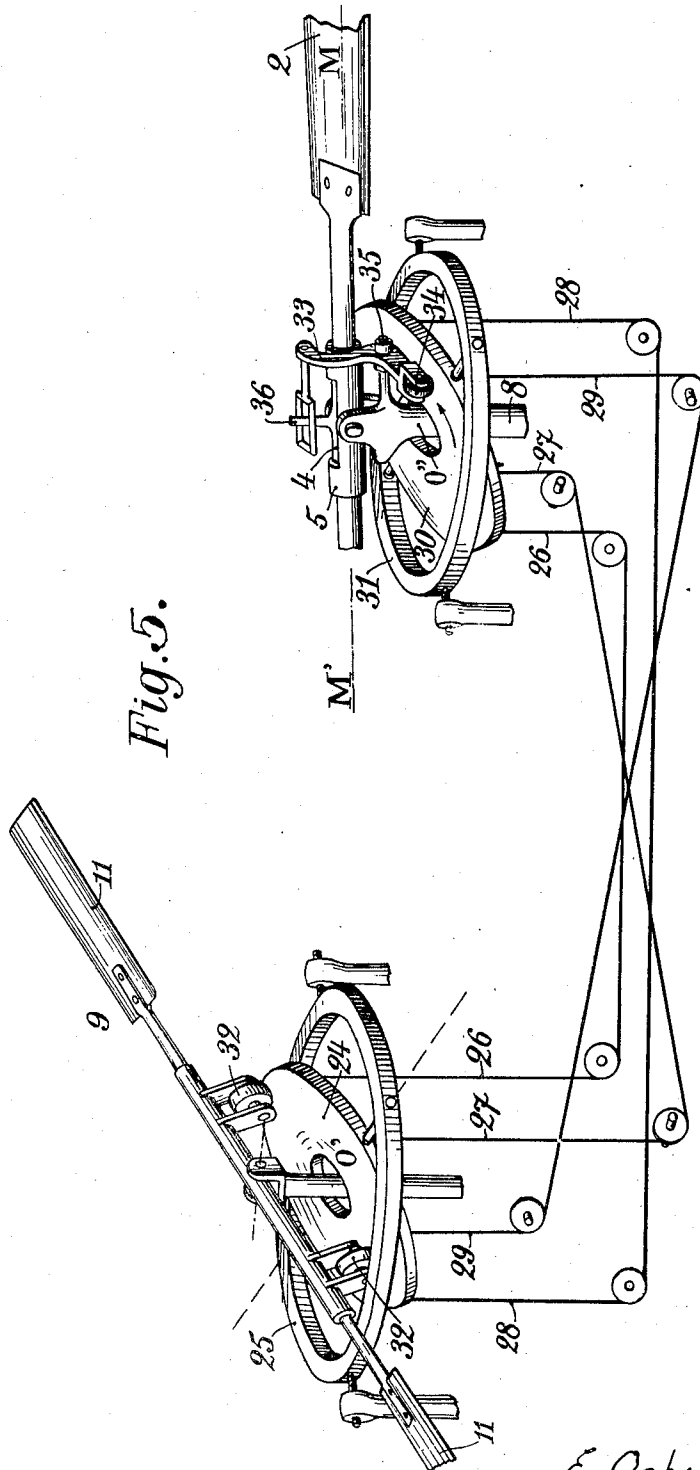
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4 Sheets-Sheet 3

Fig. 5.



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4 Sheets-Sheet 4

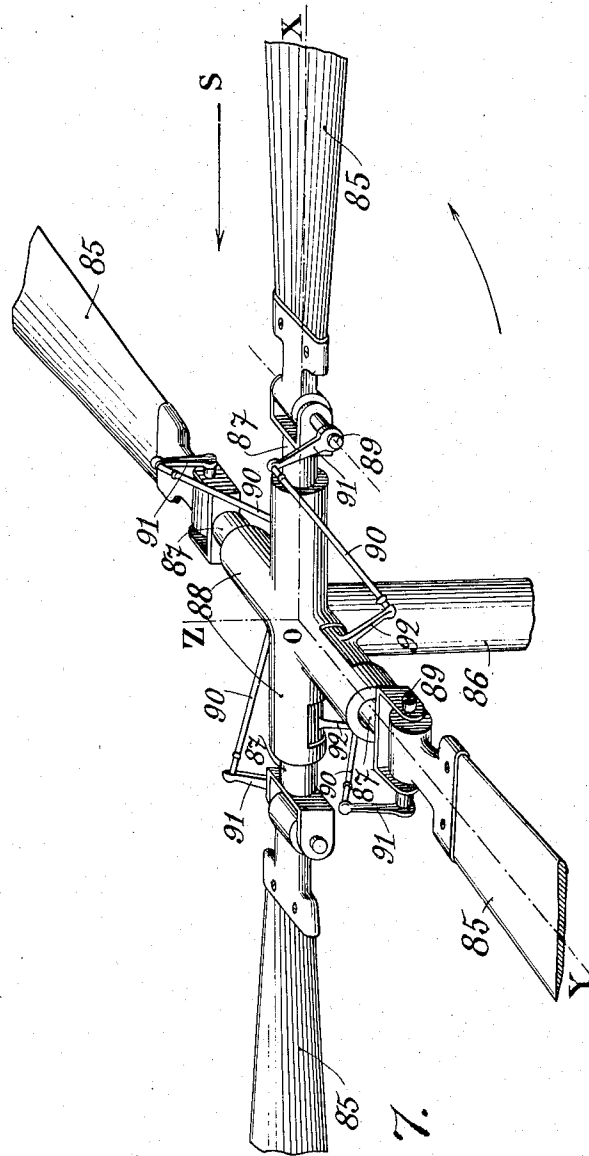


Fig. 7.

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SUSTAINING DEVICE WITH REGULATORS

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The present invention relates to a sustaining device provided with an automatic regulator which serves to regulate the reactions of the air upon the elements of the sustaining device, or to provide for its self-rotation under the effect of a relative wind.

The appended drawings which are shown by way of example relate particularly to the case of a sustaining propeller, but the invention is applicable in general to all sustaining devices, and more generally to all propellers subjected to the action of a relative wind which is not parallel to their axis of rotation.

Figs. 1 and 2 are explanatory diagrams.

Fig. 3 is a perspective view of an embodiment of the invention.

Fig. 4 is a perspective view showing a modification of the mechanism connecting a blade of the regulator with a blade of the sustaining propeller.

Fig. 5 is a perspective view of another modification.

Fig. 6 is a diagram relating to a self-rotating apparatus.

Fig. 7 is a perspective view of a constructional form of improved sustaining devices in accordance with the invention.

Under the action of a relative wind which is not parallel to the axis of the sustaining device, or simply due to a lack of homogeneity, either temporary or permanent, in the aerodynamic field, the reactions of the air on one of the blades of the sustaining device at the different points of its revolution will pass alternately through a maximum and a minimum, which are practically situated on the same diameter of a circle described by the said blade.

If the plane of Fig. 1 represents the plane of rotation of the sustaining device (said plane being first supposed invariably perpendicular to the axis O of the control shaft), C the circumference described by any part or element s of a blade whose incidence will be first considered as constant, V the component (in the plane of rotation) of a relative wind which is not parallel to the axis, and N the point of the circumference at which the vertical reaction of the air on

the element s passes through a maximum, the minimum reaction will take place at a point N' which is practically situated on the line OX' which is the extension of OX.

The vertical reactions of the air on the said element of the blade will thus admit a plane of symmetry which is the axial plane represented by XX', and they may be represented by a periodic function which is symmetrical with reference to XX'.

Any cause of a lack of equilibrium such as the action of the wind V will thus be finally manifested by a couple situated in the axial plane represented by XX' which will herein be designated as the plane of the maximum lack of equilibrium or unbalancing.

If it is desired to restore the balance, this may be done by giving to the incidence of the said element of the blade a periodic variation by which this incidence will pass through a point at which the reaction of the air tends to be a maximum, i. e. at N, and through a minimum at the point at which the said reaction tends to be a minimum, i. e. at N'. Otherwise stated, the correction for the incidence should pass through a maximum when the said element itself passes in the plane of the maximum unbalancing.

This being admitted, if the apparatus contains but a single propeller, the anti-rotation of the frame being counteracted by special means, the gyroscopic action of the sustaining device which is freely exercised will cause the reversal of the axis of rotation of the said sustaining device in the axial plane represented by OY, perpendicular to OX, irrespectively of the speed of rotation.

The axis of the sustaining device, which is out of balance and is supposed to be free, will rotate about the center of gravity which is supposed to be situated upon the same axis, not in the plane of maximum unbalancing but in another axial plane which is perpendicular thereto; this axial plane which is represented by OY will be herein designated as the reversing plane.

The maximum correction which should always be made in the plane of maximum unbalancing will thus occur in a plane perpendicular to the said reversing plane.

If the apparatus comprises several propellers rotating in the same direction, the action will be exactly the same.

Should the apparatus comprise propellers disposed in pairs, whereof the two equal elements or parts rotate in opposite directions, the gyroscopic effects will be mutually annulled.

Let C and C_1 (Fig. 2) represent the projections of circumferences described by two propeller elements which have different radii and pertain respectively to two inversely-disposed propellers of a given group, the plane of the maximum unbalancing of the propeller which contains the element s will be represented by OX and the plane of unbalancing of the propeller containing the element s_1 will be represented by OX_1 . The centers of pressure (which are off the center line) of the two propellers will be situated respectively on OX and OX_1 at the points P and P_1 such that OP will be substantially equal to OP_1 . The resulting center will thus be situated at P'' which is the middle point of PP_1 , and the reversing plane will be represented by OP'' .

The correction for the incidence should be made in such manner that its maximum shall not be situated in the plane perpendicular to the plane of reversal of the aggregate, but respectively in the planes OX for the propeller C and OX_1 for the propeller C_1 , i. e. for each propeller in a plane perpendicular to the plane of reversal of the sustaining device which is supposed to be isolated.

The invention is applied in practice for the following purposes:

1. It is applicable in the case of an apparatus which comprises propellers all of which rotate in the same direction, and this class will comprise as a particular case, the use of a single propeller which will be chosen as typical.

2. It is applicable in the case of an apparatus comprising groups of propellers rotating in pairs in contrary directions.

3. This case relates to propellers rotating in the same direction, or more simply, to a single propeller.

In Fig. 3, 1 is a sustaining propeller which will be supposed for the sake of simplicity to comprise only two blades 2 and 3. For convenience in the description, the said blades are supposed to consist of two flat rectangular elements which are rigidly secured to a bar 4 whose axis is MM' , and are spaced apart by the proper angle.

The bar 4 is rotatable on its axis in a guide tube 5 which is mounted on one of the journals 6 whose axis is HH' of a forked bracket 7 pertaining to the power shafts 8 whose axis is ZZ' . The tube 5 is rotatable on the axis HH' , so that the bar 4 is free to oscillate in the two directions $+\rho - \rho$ and $+\rho' - \rho'$.

Upon the extended part of the power shaft 8 is mounted a second rotating element or

regulator 9 which is usually smaller than the sustaining device. The said regulator herein comprises a bar 10 which is rotatable on a transverse axis $11'$ which is mounted on the power shaft and is perpendicular to the axis ZZ' of the latter. The bar 10 carries two small blades 11, which may be regulated for any suitable incidence whether positive, negative or nil, and whose centers of thrust P and P_1 are situated in the plane $ZZ' HH'$ or near this plane.

The regulator is connected with the sustaining device by mechanical connecting parts which are so disposed that any angular displacement of the regulator 9 on the axis $11'$ which causes the ascent of the point P_1 through a given distance, will rotate the bar 4 in the direction of $+\rho$ corresponding to a diminution of the incidence of the blade 2 which also has a given value, irrespectively of the inclination of the said bar about the axis HH' .

In Fig. 3, the connection comprises a rigid strap 12, which is rigidly connected with the bar 4 and is so disposed that when the incidences of the blades 2 and 3 are equal, the plane of the said strap will pass through HH' ; to an arm 13 secured to the shaft 8 is pivoted—on an axis JJ' parallel to $11'$ —a lever 14 whose ends are connected, by the links 15 and 16, at one end with the bar 10 and at the other end with the strap 12.

In this particular case, the principle of the invention consists in the use of a regulator which is directly actuated by the power shaft and is maintained in an axial plane $P' ZZ' P_1$, which is different from the axial plane $M ZZ' M'$ of the main propeller, which is mounted on the same shaft and may act upon the absolute incidence of said propeller.

The invention is independent of the method of mechanical connection employed to transmit the motion of the regulator to the blades of the propeller in the desired manner. It is an easy matter to attain the same mechanical result by the use of flexible connections, rack and pinion devices, eccentrics, cams, servo-motor control, relays, or the like.

The operation of the apparatus is at once reduced from the preceding considerations.

Since the rotation of the bar 4 in the direction $+\rho$ (Fig. 3) causes a diminution of the incidence of the blade 2 and an increase of the incidence of the blade 3, due to the action of the regulator, this will effect the desired regulation, and will automatically balance the reactions at the time and in the direction desired.

In this manner the system will automatically equilibrate the reactions of the air on the blades and will tend to cause their resultant to pass through the axis ZZ' , and this avoids imparting any reversing couples to the apparatus. However, the sustaining device

is still pivoted at HH' and may thus be inclined in case of any residual unbalancing which has not sufficiently corrected the rotation of the bar 4. This inclination has a double advantage, since it imparts to the entire system only the reactions passing through HH', and it also completes the regulating by changing the absolute angle of incidence with reference to the air. The blade which is the most loaded will rise while also rotating, and its absolute angle of incidence will decrease due to this ascent, and its trajectory tends to become parallel to the plane of the blade. The blade which is the least loaded will descend, and its absolute incidence increases in like manner.

The regulator, instead of being mounted on the shaft 8 at exactly 90 degrees from the sustaining device, may be set at a different angle, so as to take account of the interactions of the regulator and the sustaining device. It will not be entirely without useful effect, unless it were set in the same plane as the sustaining device, and it may be noted that a certain adjustment in the setting on either side of the right angle plane is always required.

The system is irreversible when the centers of pressure of the blades 2 and 3 are situated on the axis MM' of the bar 4 as also their center of gravity, thus obviating all couples tending to return the blades about MM' to any given incidence, by aerodynamic or by mechanical action.

The inclination of the bar 4 about HH' produces a centrifugal return couple which tends to make the plane of rotation of the blades perpendicular to OX. This couple should not be counteracted, since it gives the propeller a position of general equilibrium.

To increase the power of the regulator, the bar 10 may be so disposed as to rotate on its axis with facility, in the same manner as the bar 4 of the sustaining device, and herein the oscillations of the regulator are increased, and the power of the control is augmented, this allows to increase or to reduce at will the incidence of the blades by known means if one deems it necessary to correct the automatic action of the regulator.

A regulator may also be constructed in which the bar 10 is not pivoted on 11', and in which the blades are simply pivoted on the bar 10, or the respective bars 10, and are disposed singly or in pairs, but such a device has but little power.

A single blade of the regulator may serve for the control of one or more blades of the sustaining device, and I may modify the means of connection of the blades of the sustaining device or the regulator, or of both, for instance as shown in Fig. 4; herein the blades 11 of the regulator are not mounted in pairs but are separately pivoted, in a manner known per se, about horizontal axes such

as 17, and are maintained in equilibrium by centrifugal force and by the reaction of the air. The blades 2 and 3 of the sustaining device may be disposed as shown in Fig. 3 or may be separately pivoted like the blades of the regulator; this latter case is shown in Fig. 4. Their pivot axle 18 is mounted in a forked bracket 19 movable on an axle 20 secured to the power shaft 8; said bracket will pivot on the axle 20 in conjunction with the pivotation of the blade 11 about the axis 17, for instance by transmission means comprising a pinion 21 secured to the blade 11, a pinion 22 secured to the bracket 19 and a rack 23 which is guided parallel with the shaft 8 and coacting with these two pinions.

When the blade 11 rises or descends, the incidence of the blade 2 will respectively decrease or increase.

In the different cases herein specified the reactions of the air on the blades of the regulator, combined with the gyroscopic effects, cause them to rise about an axis corresponding to the position in which the said blades are subjected to the maximum and minimum reactions of the air. A combination of levers or like controls such as are shown in Fig. 3 or Fig. 4, will pivot the blades of the sustaining device about their axis 20, so as to reduce their incidence to the minimum at the points at which the reaction of the air tends to pass through a maximum, and vice-versa.

The pivot axes 17 of the regulator blades may also be movable about auxiliary axes which are parallel to the lengthwise direction of said blades or are perpendicular to the axes 17 and to the axis ZZ'. In spite of this added freedom, the blades will tend to assume a position of equilibrium if their centers of gravity are situated, relatively to the movement, in the rear of the planes passing through these auxiliary axes and through the axis ZZ'.

I may further construct a regulator which rotates at a different speed from that of the main sustaining device, and which is even quite independent of the latter as concerns its rate of rotation.

Fig. 5 is a diagrammatic view showing this construction; 9 is the regulator, whose plane of rotation becomes inclined under the action of the relative wind. The rollers 32 mounted on the regulator roll upon a circular disk or race 24 which is mounted in a Cardan ring 25 whose center is O'. The cable connections 26—27—28—29 transmit to a second roller race 30—also mounted in a Cardan ring 31—movements which reproduce in space the movements of 24, or symmetrical movements. If the center O'' of the ring 31 is situated upon the shaft 8 carrying the sustaining device, it is simply necessary to dispose the lever or levers controlling the inclination of the blades 2 and 3 such as 33 so that they will be

obliged to roll at their end provided with a roller 34 upon the race 30, in order to produce at the proper moment the desired incidence of these blades 2 and 3.

5 In the construction shown in Fig. 6, the lever 33 is pivoted on an axle 35 mounted on the shaft 8, and it controls an arm 36 secured to the bar 4 carrying the blades 2 and 3. The socket 5 in which the said bar is rotatable
10 is recessed so as to allow the arm 36 to pivot about the axis MM' of the bar 4.

By changing the position of the supporting pulleys of the cable gear, or by regulating them in any other suitable manner, or by
15 changing the direction of the supports of the Cardan rings 25 and 31, it is an easy matter to provide any desired angular spacing of the pivoting movements of the sustaining device with reference to the movements of
20 the regulator.

Any other suitable power transmission devices may be employed, without modifying the invention, since its principle consists in the use of a separate and distinct regulator
25 whose elements—modified as to position of incidence by the relative wind itself—react upon the main sustaining device so as to correct the incidence and the trajectory at the proper points.

30 The regulator may serve in an efficient manner to assure the self-rotation of the sustaining device under the action of a transverse relative wind, without making it necessary, as in the known apparatus of this
35 class, to incline the axis of rotation ZZ' with reference to the relative wind.

With the sustaining device in the position shown in Fig. 3, if the operator inverts by a
40 suitable action the incidence of the planes 2 and 3 while also reversing the incidence of the regulator blades 11, this will afford the arrangement shown in Fig. 6.

Σ_1 indicates the direction of motion of the blade 2 which is situated at this time in front
45 of the plane of the figure on the axis ZZ', and Σ_2 the direction of motion of the blade 3 which is moving to the rear.

The relative wind which has the direction of S will incline the plane of rotation of the
50 regulator according to π' . The blades 2 which move against the wind, assume an angle of incidence which is small and positive; the blades 3 which move backward before the wind assume an incidence which is
55 large and positive, the bar 4 rotating in the direction $-\rho$ (Fig. 3). Both blades have a lifting action; one is actuating and the other actuated, and if the controls are properly regulated, the self-rotation will be main-
60 tained upon the balanced sustaining device.

In this case, the correction of the incidence is effected by a system which operates auto-
65 matically, but the same effect can be obtained by hand, by the use of a steering device; but as the reflex reactions of the pilot will nec-

essarily cause him to bring the balancing element into the reversing plane of the apparatus, the control must be set back by 90 degrees with reference to the blades, so that the
70 movements of equilibrium will be manifested by a maximum correction in a plane perpendicular to the one in which the said movements are effected.

For this reason it is necessary to act by means of a balancing device, not as in certain known apparatus by bringing the maxi-
75 mum of the correction into the plane of the reversal, but by bringing it into a plane perpendicular thereto, by suitable means for transmitting the motion.

The device which serves for this control, with the desired angle of spacing, may have a widely varying construction. It may be
80 constructed in a very simple manner as follows, by the use of a system analogous to the one described with reference to Fig. 5.

The controlling wires 26—27—28—29 which are connected with the disk 30, are
85 herein connected with the pilot's control stick, so that the operating of the wires 26 and 28 (for example) will pass through a maximum amplitude for an operation of the control stick which takes place in a plane
90 perpendicular to the plane 26—28; the direction in which the wires 26 and 28 are to be moved will obviously depend upon the direc-
95 tion of rotation of the sustaining device, which is determined once for all. This supposes that the length of the lever 33 is negligible as compared with the diameter of the
100 disk.

I may however increase the size of the lever 33, and in this case it is so disposed that the point of contact of the roller 34 with the
105 drum 30 is situated in a plane perpendicular to the axial plane containing MM'. In these conditions, the disk 30 is moved by the controls in such manner that the line of the greatest slope will be constantly in an axial
110 plane parallel to the plane of the maximum displacement of the equilibrating device.

In this case as in the other, it will be observed that the principle of the invention is carried into effect in the following manner:
115 The control of the variation of the incidence produces the maximum and the minimum incidence in a plane perpendicular to the plane of the manipulation of the balancing device or control stick, and consequently to the plane of reversal.
120

Any suitable power transmission gear may be employed without any change in this principle. In this manner, if a regulator 9 of the type herein described is already in use, I may
125 vary the incidence of the blades of the said regulator so as to change the amplitude of the pivoting motion, and hence to change the amount of the correction for the incidence of the blades 2 of the main sustaining device, in
130 order to correct the action of the regulator

itself which may be too strong or too weak. This adjustment, of the regulator by changing the incidence of its own blades may be performed in the known manner.

I may further dispose upon the regulator a disk which may be inclined as desired, for instance the said disk 24 whose inclination may be controlled by suitable power transmission gear which is connected with the control stick so as to cause variations in the inclination of the said disk 24 and hence in the plane of rotation of the regulator due to the pilot's reflex action, and herein the device will appear as shown in Fig. 7 which is a combination of Figs. 3 and 5.

In this Figure 7, 41 indicates the blades of the sustaining device which are secured to a bar 42 which is revoluble in a socket 43 mounted on the shaft of the engine 42, guided through the stationary tube 45; upon the latter a Cardan ring 46 is pivoted on the axles 47 and supports—by the axles 48—the ring or disk 49 which is under the control of the regulator.

The said regulator comprises the blades 50 which are secured to a bar 51 pivoted on a transverse axle 52 which is supported by two straps 53 secured to the socket 43, the axle 52 being parallel to the bar 42 of the sustaining device.

The regulator controls the incidence of the blades 41 by a fork 54 which is secured to the bar 51 and acts upon a strap 55 mounted on the bar 42; to oblige the Cardan disk 49 to pivot about while remaining parallel to the bar 51 of the regulator, I may provide two links 56 which are pivoted by the axles 57 to the bars 51 and by the ball-and-socket joints 58 to a collar 59 which is guided upon the periphery of the disk 49 so as to rotate by easy friction upon the latter.

The pivotation which the regulator thus imparts to the disk 49 during its rotation is transmitted by the wires 60—61—62—63 to the pilot's steering gear, which comprises a shaft 64 mounted in a stationary support 65 and provided with a transverse axle 66 to which is pivoted a lever or control stick 67; upon the shaft 64 is also mounted an arm 68. The points $d\ d'$ at which the wires 60—61 are attached to the disk 49 are disposed in the diametrical plane passing through the axis of the bar 51; the other ends of said wires are attached to the control stick respectively above and below its pivot axle 66, and said wires are disposed upon the suitably placed supporting rollers 70. The points at which the wires 62 and 63 are attached to the disk 49 are situated on a diameter $e\ e'$ which is perpendicular to the diameter $d\ d'$ passing through the attaching points of the wires 60—61, and the wires 62—63 are guided by the rollers 71 and are attached to a common point on the arm 68.

The arrows represented in Fig. 7 show

that if the handle of the control stick is moved for instance perpendicularly to the plane of the figure, towards the spectator, which corresponds to the direction of rotation $f_1\ f_2$ about the axes 66—64, the disk 49 will be obliged to pivot at the same time about the diameters $d\ d'$ and $e\ e'$ in the direction of the arrows $f_3\ f_4$, so that its lowest point, which is now on the side next the spectator, will be brought to the right hand. In other words, the shaft 44 being supposed to be vertical, the diameter of the greatest slope of the disk 49 will always be maintained in a vertical plane situated at 90 degrees from the direction given to the control stick.

Due to this cooperation of the disk 49 and consequently of the regulator 50 with the control stick, this latter may be left free by the pilot, and the regulator then acts alone upon the incidence of the blades of the sustaining device through the medium of the fork 54 and the strap 55.

If the pilot operates the control stick, he may modify the action of the regulator at will and may correct the effects of the regulating of the incidence on the main blades 41 of the sustaining device either to increase the said effects, or to diminish these effects, or to change their direction.

In this form of construction as in the preceding, the connection between the control stick and the regulator is such that the manipulations of the control stick in the reversing plane are still manifested by a maximum correction for incidence when the blades of the sustaining device are situated in the maximum plane of unbalancing.

Numerous modifications of the aforesaid devices may be made without changing the general principle, i. e. the perpendicular relation between the reversing planes and the maximum plane of correction.

I may even construct apparatus in which the connection between the stabilizing element and the blades of the sustaining propeller is not effected by flexible or rigid means such as cables, levers, screws, eccentrics or the like, but by relays of the electric, hydraulic, pneumatic or other type, whereby an efficient control may be obtained with the use of a very small corrective power.

In such conditions, I may regulate the incidence of the blades at the proper point by the use of any suitable regulating device, whether of the pendulum or the gyroscope type, which operates by the inclination of the apparatus and which controls by means of electric contacts (or the like) the element which regulates the incidence of the propeller. In this case as before, the operation of the blades will take place in a plane perpendicular to the reversing plane.

As observed, the incidence of a propeller may be regulated in different manners, either by rotating the blade about an axis perpendic-

ular to the shaft carrying the propeller and parallel with the large axis of the blade, or by the displacement of the entire blade, either parallel to itself or by an angular movement, about an axis which is perpendicular to the propeller shaft and also to the large axis of the blade.

The last two methods for varying the incidence may be considered as variations in the incidence by the trajectory of the blade; in fact, if the blade is raised while rotating, its absolute incidence with reference to the air is reduced, but if it descends while rotating, this incidence is increased, and the final result is the same as in the preceding case.

The aforesaid correction will therefore be applicable not only to the simple rotation of a blade upon its axis, but to the effective correction of the incidence corresponding to the maximum reactions of the air upon the blade, and it is necessary to produce this reaction in a plane perpendicular to the reversing plane.

If the question relates, as a particular case, to a blade which is adapted for displacement, the minimum incidence will occur at the point at which the angular speed of ascent of the blade is the greatest, and the maximum incidence will occur at the point at which the speed of the descent is the greatest.

(1) Case in which groups of propellers rotate in pairs in opposite directions.

If the apparatus comprises propellers which rotate in pairs in opposite directions, the same principles are applicable, and herein each propeller is separately controlled by the stabilizing device so that the maximum correction takes place in the plane perpendicular to the reversing plane of the said propeller which is supposed to be isolated. These planes are not put in evidence when the apparatus is unbalanced.

However the angles $P''OP = P''OP^1$ (Fig. 2) are practically constant for a given apparatus, and may be determined a priori. As a rule, these angles are near 65 degrees. I dispose the transmission gear of the controls in such manner that the maxima of the correction for the incidence will take place, for each propeller of a given group, in axial planes which form angles of about +65 and -65 degrees with the reversing plane which may also be termed the steering plane.

(2) Modified arrangement of the regulator.

I may employ for correcting purposes a system in which the regulator concurs in the general sustaining of the apparatus.

Fig. 7 shows such an arrangement, in which the regulator comprises four blades 85 which are mounted on the driving shaft 86 by means of Cardan devices, each of which comprises a shaft 87 mounted in a socket 88 secured to the shaft 86, and a shaft 89 perpendicular to the shaft 87 and carrying the blade; the

four shafts 87 are disposed at right angles about the shaft 86, and in this manner each blade can be given a double movement, firstly a movement of ascent or of pivotation on the shaft 89, and secondly a movement of pivotation of the blade on its longitudinal axis.

Suitable transmission gear which connects two consecutive blades permits of obtaining, by the pivotation of each blade on the shaft 89, the rotation of the next blade on its longitudinal axis, so that if one of the blades should tend to rise, it will tend to rotate the next blade in such manner as to reduce its incidence.

All of the blades are thus connected together in pairs, and it will be noted when considering any two consecutive blades that the first blade acts in the same manner as the regulator blade and that the second blade acts as a sustaining blade, so that all of the blades will serve in turn as regulating blades and as main blades, without differing in their construction.

In the present case, the two consecutive blades are connected together by a link 90 whose respective ends are pivoted to the arms 91, 92 which are mounted respectively on the shafts 89 of one blade and the shaft 87 of the succeeding blade. The connection may be made in any other suitable manner. The blades may be connected together in oppositely disposed pairs, or may be made independent, without affecting the principle.

Instead of a rotation of a blade which is under the control of the preceding blade, I may produce simply a warping of the said blade, which has the same effect as concerns the incidence. This arrangement is in fact only a modification of the above described constructions, but with the difference that each blade serves for regulating and sustaining purposes in turn.

It is thus observed that a relative wind whose direction is S will tend to cause the maximum ascent of the blades which are pivoted in the plane XOZ perpendicular to the plane of maximum unbalancing YOZ, and that this ascent affords precisely the maximum correction of incidence on a blade situated at 90 degrees from the preceding and thus passing through the point of maximum unbalancing, which is in conformity to the general principle of the invention.

It is further evident that all devices operating by the direct action of the relative wind which is not parallel to the axis and producing the maximum correction of the incidence in the plane of the maximum unbalancing, will be covered by the principle of the invention.

In this manner it may be supposed that a rotatable plane, analogous to a weather vane, is disposed on the apparatus in such manner that it will be affected by the relative wind, and that the movements of the said vane, by

means of suitable gear, will cause the desired variations of incidence in the plane of maximum unbalancing. As stated, this plane may be considered as forming a practically constant angle with the direction of the relative wind. This angle, which is the complement of the angle α of Fig. 1, is 65 degrees on the average. It may be found with great accuracy for each sustaining device, if the speed of rotation of the device is known, and herein the controls of the system affected by the wind will act in such a manner as to offer a maximum correction in the plane forming the angle α with the axial plane parallel to the relative wind.

Having thus described my apparatus, what I claim as new therein, and my own invention, is:—

1. In a sustaining device, the combination of sustaining blades which rotate in a continuous manner upon a main axis and whose incidence is variable, a so-called regulating rotary propeller adapted to cause the incidence of the sustaining blades to vary and to pivot about its center of rotation, whereby its plane of rotation will make with the plane of rotation of the sustaining blades, a variable angle under the effects of wind, means for the transmission of motion between the regulating propeller and the sustaining blades for transforming the movement of inclination of the plane of rotation of the regulator so as to correct the incidence of the sustaining blades, the said transmission means being adjusted in such manner that the correction of incidence of every sustaining blade will be at any moment proportional to the angle of inclination made by a radial linear element of the regulating propeller, situated in the plane of rotation of the latter and turned of 90° in advance of the longitudinal axis of the corresponding sustaining blade, with the plane of rotation of the sustaining blades.

2. In a sustaining device, the combination of sustaining blades which rotate in a continuous manner upon a main axis and whose incidence is variable, a regulating propeller adapted to cause the incidence of the sustaining blades to vary and turning at the same speed as the sustaining blades, the said regulating propeller being adapted to pivot freely about an axis which is perpendicular to its axis of rotation and connecting means connected, on the one hand, to an element of the regulating propeller, situated both in the plane of rotation of the latter and on a radius perpendicular to the said axis of oscillation of the said regulating propeller and, on the other hand, to an element of the sustaining blades.

3. In a sustaining device, the combination of sustaining blades which rotate in a continuous manner on a main axis and whose incidence is variable, a regulating propeller adapted to cause the incidence of the sustain-

ing blades to vary and turning at the same speed as the sustaining blades, the said regulating propeller being adapted to pivot freely about an axis which is perpendicular to its axis of rotation and parallel to the longitudinal axis of the sustaining blades, a rod articulated to an element of the regulating propeller situated in the plane of rotation thereof and on a radius perpendicular to the axis of oscillation of the said propeller, a two-arm lever pivoting on a support rotating with the main shaft of the sustaining device and one arm of which is articulated to the said rod, an arc connected to the sustaining blades, a second rod articulated to the said arc, on the one hand, and to the other arm of the said lever, on the other hand.

4. A sustaining device including the combination of sustaining blades which rotate in a continuous manner about a main axis, and the incidence of which is variable, regulating blades which rotate about an axis parallel to the main one, the said regulating blades being besides able of oscillating about an axis perpendicular to their rotation axis, and means connecting the said sustaining blades with the said regulating ones, the said means being adjusted in such manner that the incidence of each sustaining blade be at any moment proportional to the angle of inclination of the plane of rotation of the regulating blades upon their rotation axis, in a plane perpendicular to the axial plane containing the considered sustaining blade.

5. A sustaining device including the combination of sustaining blades which rotate in a continuous manner about a main axis, and the incidence of which is variable, regulating blades which rotate about another axis, parallel to the main one, at the same speed as the said sustaining blades, the said regulating blades being besides able of rotating about an axis, which is perpendicular to their rotation axis, and connecting means connected, on the one hand, to the plane of rotation of the sustaining blades, and, on the other hand, to the incidence of the sustaining blades, and characterized by the fact that the longitudinal axis of each regulating blade is situated in a plane which is perpendicular to the plane of the corresponding sustaining blade.

6. A sustaining device including the combination of sustaining blades which rotate in a continuous manner about a main axis, and the incidence of which is variable, regulating blades, in equal number to that of the sustaining ones, which rotate about a rotation axis parallel to the main one at the same speed as the sustaining blades, the longitudinal axis of each regulating blade being situated in a plane perpendicular to the rotation axis of the corresponding sustaining blade, the said regulating blades oscillating besides freely about an axis perpendicular to their rotation axis, and connecting means between

each regulating blade and the corresponding sustaining one, including rods and articulations which are connected, on the one hand, to the said regulating blade, and, on the other hand, to the corresponding sustaining one, the said connecting means being so adjusted that the maximum inclination of the regulating blade brings on the maximum incidence of the corresponding sustaining blade.

7. A sustaining device including the combination of sustaining blades which rotate in a continuous manner about a main axis, and the incidence of which is variable, the said sustaining blades being beside able of oscillating freely about an axis perpendicular to their rotation axis, and regulating blades, in equal number to that of the sustaining ones, rotating about an axis which is parallel to the main one, at the same speed as the sustaining blades, the longitudinal axis of each regulating blade being situated in a plane which is perpendicular to the longitudinal axis of the corresponding blade.

8. A sustaining device including the combination of sustaining blades which rotate in a continuous manner about a main axis, the said blades being besides able of rotating about their longitudinal axis, so that their incidence is variable, and regulating blades which also rotate about the same main axis, the longitudinal axis of each regulating blade being situated in a plane perpendicular to the longitudinal axis of the corresponding sustaining blade.

9. A sustaining device including the combination of sustaining blades which rotate in a continuous manner about a main rotation axis, the said blades being able of rotating about their longitudinal axis, so that their incidence is variable, the said sustaining blades being besides able of oscillating about an axis perpendicular to their rotation axis, and regulating blades which also rotate about the said main axis, and are articulated round an axis perpendicular to the said main one, the longitudinal axis of each regulating blade being situated in a plane perpendicular to the one of the corresponding sustaining blade.

10. In a sustaining device, the combination of sustaining blades rotating in a continuous manner about a main axis of rotation and the incidence of which is variable, regulating blades rotating in a continuous manner about an axis parallel to the said main axis, the said regulating blades moreover free to oscillate about their center of rotation, so that their plane of rotation can incline according to a variable angle under the action of the wind, and connecting means between the regulating blades and the sustaining blades, so adapted that the inclination of the plane of rotation of the regulating blades controls the variation of the incidence of the sustaining blades, characterized in that the angle

of incidence of each sustaining blade is at every instant proportional to the angle formed by the axis of rotation of the regulating blades and the straight line intersecting the plane of rotation of the said blades and the plane perpendicular to the axial plane containing the sustaining blade under consideration.

11. In a sustaining device, the combination of sustaining blades rotating in a continuous manner about a main axis of rotation and the incidence of which is variable, the said blades being moreover free to oscillate about an axis perpendicular to their longitudinal axis, regulating blades rotating in a continuous manner about an axis parallel to the said main axis at the same speed as the said sustaining blades, the said regulating blades being moreover free to oscillate about an axis perpendicular to their longitudinal axis, so that their plane of rotation can incline according to a variable angle under the action of the wind, and mechanical connecting means connected, on the one hand, to an element rigid with the regulating propeller and located on a radius perpendicular to the axis of oscillation of the said propeller and, on the other hand, to an element rigid with the sustaining blades.

12. In a sustaining device, the combination of sustaining blades rotating in a continuous manner about a main axis of rotation and the incidence of which is variable, the said blades being moreover free to oscillate about an axis perpendicular to their longitudinal axis, regulating blades equal in number to the sustaining blades and rotating in a continuous manner about an axis parallel to the said main axis at the same speed as the said sustaining blades, the longitudinal axis of each regulating blade being situated in a plane perpendicular to the longitudinal axis of the corresponding sustaining blade, the said regulating blades being moreover free to oscillate about an axis perpendicular to their longitudinal axis, so that their plane of rotation can incline according to a variable angle under the action of the wind, and connecting means connected, on the one hand, to an element rigid with the regulating propeller and situated on a radius perpendicular to the axis of oscillation of the said propeller and, on the other hand, to an element rigid with the corresponding sustaining blade.

13. In a sustaining device, the combination of sustaining blades rotating in a continuous manner about a main axis of rotation and the incidence of which is variable, regulating blades equal in number to the sustaining blades, and rotating themselves about the said main axis at the same speed as the said sustaining blades, the longitudinal axis of each regulating blade being situated in a plane perpendicular to the longitudinal axis

of the corresponding sustaining blade, the said regulating blades being moreover free to oscillate about an axis perpendicular to their longitudinal axis, so that their plane of rotation can incline according to a variable angle under the action of the wind, and connecting means connected, on the one hand, to an element rigid with the regulating propeller and situated on a radius perpendicular to the axis of oscillation of the said propeller and, on the other hand, to an element rigid with the corresponding sustaining blade.

14. In a sustaining device, the combination of sustaining blades rotating in a continuous manner about a main axis of rotation and the incidence of which is variable, the said blades being moreover free to oscillate about an axis perpendicular to their longitudinal axis, regulating blades equal in number to the sustaining blades and rotating themselves about the said main axis at the same speed as the said sustaining blades, the longitudinal axis of each regulating blade being situated in a plane perpendicular to the longitudinal axis of the corresponding sustaining blade, the said regulating blades being moreover free to oscillate about an axis perpendicular to their longitudinal axis, so that their plane of rotation can incline according to a variable angle under the action of the wind, a rod jointed to an element situated in the plane of rotation of the regulating propeller and on a radius perpendicular to the axis of oscillation of the said propeller, a two-arm lever rocking on a support rotating with the main shaft of the sustaining device, and one of the arms of which is pivoted to the said rod, an arcuate member rigid with the sustaining blades, a second rod pivoted, on the one hand, on the said arcuate member and, on the other hand, on the other arm of the said lever.

In testimony whereof I have hereunto affixed my signature.

ETIENNE OEHMICHEN.

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