Automatic Stability of Aeroplanes

Comments on Some American Patents

By Grover Cleveland Loening, Author of "Monoplanes and Biplanes"

AS FLYING becomes more general, the treacherous and shifty character of the air-ocean is more and more fully appreciated. The vast swirls and turmoils of the air are felt distinctly by all aviators, and the manner in which aeroplanes are wafted about on unseen billows and through invisible cross-currents is now familiar to many. One has only to watch for a few moments an aeroplane and its driver in full flight, silhouetted against the blue of the sky, to observe the ceaseless motions of the aviator closely following the equally continuous quivers of his fragile craft.

To fly on a gusty day does indeed tax the nerve and endurance of many men, and it has long been recognized that, although the voluntary control of aeroplanes is well-nigh perfected, yet the disturbing

2. The employment of a gyroscopic apparatus which is designed either to hold the machine in perfect equilibrium itself, or else to "precess," and in doing so, move controlling apparatus to correct any tilt.

3. The use of auxiliary planes or light vanes, that travel in the air stream and upon a sudden inclination of the aeroplane, by their continual drifting in about the same line, cause the movement of rudders for the correction of the equilibrium.

4. The construction of the aeroplane of such materials and in such a manner that it possesses of itself an inherent elasticity, which causes it to be suspended in its element like a carriage on its springs. The Bréguet and Paulhan biplanes are notable types of this kind.

5. A rigid structure of such a form that it possesses a kind of automatic stability. The old Voisin, Pischhof, Etrich, Warchalowsky and Dunne are types of this kind. There may be also included in this class all those types employing the dihedral principle either laterally or longitudinally.

6. The use of the movement of a compass needle to set apparatus in motion that will move the rudder so as to correct any deviation in direction; and the use of the movement of a barometer needle or other apparatus affected by the pressure of the air to control the rudders for altitude.

I

The manner in which a pendulum device is relied upon to give automatic control is best shown by reference to Figs. 12, 13 and 14. Fig. 12 represents a longitudinal section of an aeroplane, showing a pendulum control *P* for fore and aft balance and an elevator rudder *E*. The direction of flight is indicated by the arrow, and in this same diagram the aeroplane is assumed to be in normal horizontal flight.

Fig. 13 shows the same apparatus immediately after a sudden gust has tilted the front of the machine up. The pendulum *P*, due to its inertia, has retained its vertical position *P'*, but in doing so has pulled on the rod *ad*, causing the front elevator to assume the position *E'*, and to receive the pressure of the wind on its upper face. This causes a downward force on the rudder surface which brings the machine back to the horizontal. Fig. 14 represents the effect of a sudden downward plunge of the head of the machine.

In the same manner, the inertia of the pendulum is used to move side controls, when a sudden transverse tilt occurs.

Of course the nature of the pendulum and the manner in which it controls the equilibrium is vastly different in many of the suggested methods, but the fundamental principle is everywhere the same, the pendulum itself consisting variously of an extra weight, the weight of the car, the weight of the aviator, swinging on a movable seat, or the movement of a mercury bath.

There are four distinct objections to employing any kind of a pendulum device for automatic stability:

(a) The first and most important objection is that, if the pendulum is at all heavy, it will tend, when the machine is tilted, to accentuate greatly the tipping. Thus, in Fig. 13, due to the fact that the weight *P'* has traveled through an angle *O* with respect to the frame, there will be a strong downward pull in the direction *BA*. This will certainly accentuate the downward force at the rear, due to the vertically downward component *BC*. If the weight is heavy enough and the inclination great enough this is likely to completely unbalance the machine.

(b) Another effect upon a pendulum mechanism that makes it distinctly undesirable is that if there is a sudden lurch of the entire machine either forward or backward, or to either side, unaccompanied by any tilting, then the inertia of the pendulum will cause it to swing away from the side to which the machine lurches, thus moving the rudders and actually disturbing the equilibrium of the machine by either making it rise, plunge or tilt over to one side. Due to "holes in the air," sudden side gusts and even variable propeller thrusts, such sudden lurches are of frequent occurrence, and unless some means of "deadening" the pendulum is provided the equilibrium would be very unstable.

(c) The action of centrifugal force on making a

turn will cause the pendulum to assume a position parallel to the struts of the machine or any other normally vertical parts, and it will not fly out to the outside as commonly supposed. Its action in turning, therefore, is *nil*, and to make the turn positive it would be necessary to install a separate control. This arrangement assumes a proper "banking" of the machine.

(d) After any displacement of the pendulum itself from its normal position due to a sudden movement or lurch of the aeroplane, the pendulum will at once tend to swing back to the normal. If the period of this swing should just happen to coincide with the frequency of any vibration or sway in the machine or with any wave pulsations of the air stream, then the swinging would continue and be amplified, eventu-

1. The Pressey automatic control.

3. The J. D. Pursell patent stabilizing device. 6. Automatic controlling system patented by P. R. Torbrand.

air forces are at times so sudden and so powerful that the aviator is taken unawares—often with disastrous consequences.

A great majority hold, therefore, that before flying can become as popular as motoring some practical form of apparatus that will hold the aeroplane in equilibrium automatically must not only be devised, but be applied successfully.

The application of some methods has already taken place, and the actual operation of other methods that have been devised will doubtlessly come within the year, so that it is appropriate and important to discuss the more noteworthy schemes and some of their particular features as exemplified in the ever-growing list of patents on "automatic stability."

There are numerous methods of attaining this highly desirable end of automatic stability, the most promising ones being:

1. The employment of the inertia of a pendulum or other mass, to move or cause other agencies to move planes or rudders, for correction, as soon as the aeroplane tilts from its normal position of flight. This method is more generally suggested than any other.

2. The C. I. Lake apparatus. 4. The pivoted plane device patented by F. H. Wales. 5. The James Means patented pendulum system of automatic control.

7. A typical example of an early patented flying machine.

ally destroying the equilibrium of the machine. Synchronism of this sort is not at all unlikely to happen, for air waves are known to possess pulsations at regular time intervals; and in addition, propellers have often been found to give continuously and rhythmically varying thrusts, causing a slow swaying vibration in the aeroplane, quite distinct from the vibration of the motor.

It appears, therefore, that the use of a pendulum for preserving the stability of an aeroplane is limited in its action to the condition of comparatively steady horizontal flight, and is hardly feasible in very gusty weather.

One of the earliest devices of this sort (Fig. 11) was patented by E. P. Johnston on June 5th, 1888 (U. S. Patent No. 383,889). The flying machine described is of the helicopter type, in that it is provided with four lifting screws, two of which, *A* and *B*, are shown. Any inclination of the ship either transversely or longitudinally sets a pendulum in motion, which, by means of an electric contact, governs the operation of the motive power to the propellers, so that the lift on the depressed side is increased. In addition, it is interesting to note that the patent covers the shifting of the pendulum *P*, causing a

movement of a needle N on a dial D , thus indicating to the operator the state of equilibrium of the machine.

A similar electrical control of the power supplied to lifting propellers by a pendulum, was patented in England by I. A. Colquhoun on July 29th, 1907. Sir Hiram Maxim, on April 28th, 1897, patented, in England, a pendulum device actuated by the tilting of the machine, and thus controlling the power of the engines which drive the propellers so that the machine is automatically righted.

Sylvanus S. Morrison, on October 11th, 1910, patented a device (see Fig. 10), in which the plane is pivoted to the chassis (U. S. patent No. 972,395). The chassis C , due to its inertia, is supposed to stay in a normal position. The tilting of the plane P down on any side, by means of a suitable system of levers, shafts and gears, causes the entire motor and ordinary vertical propeller system S to be turned around on a horizontal turntable T so that the thrust of the propeller and the air thrown back by it, is directed against the lowered side, thus, due to the increased draught of air, causing it to lift up.

On March 27th, 1906, the I. C. Hansen-Ellehammer device was patented in England. It consists merely of the system shown in Figs. 12, 13 and 14, in which a simple weight is connected by a rod to an elevation rudder, and upon the tilting of the machine up or down the inertia of the weight causes the rudder to be moved for correction.

The employment of the movement of a mercury bath instead of a weight was patented by I. D. Pursell on October 22nd, 1907 (U. S. patent No. 869,019). The mercury is contained in a barrel B (see Fig. 3), and when the aeroplane tilts the mercury runs to the lowered end of the barrel, thus closing a circuit and operating an electromagnet M , which moves a lever L , causing the rudders or side warping control to be set for correction of the equilibrium.

The C. I. Lake patent of April 13th, 1909 (U. S. patent No. 918,336), covers essentially a fluid jet propelled apparatus (see Fig. 2) equipped with a pendulum P (Fig. 2a) caused to swing by the tilting of the machine, and by thus opening certain passages and changing the fluid movement, the apparatus is brought back to an even keel.

F. H. Wales, on August 2nd, 1910, patented a system for automatic stability (U. S. patent No. 965,969). The car or other heavy movable weight W (see Fig. 4) is pivoted to the frame F , and upon the tilting of the machine to any side the car, remaining normal, causes the entire plane P to be shifted bodily over to the depressed side by means of a toothed segment and rack R . The lift on the depressed side is thus increased.

On December 14th, 1909, the pioneer James Means patented a pendulum device that has many advantages because all the movements of the pendulum P (Fig. 5) and rudders R are easily in control of the aviator through a handle bar H , which is part of the pendulum lever and moves with it, thus preventing eccentric motions of the pendulum. In addition, positive voluntary movement of the rudders is possible. If the aeroplane plunges head down, the pendulum P swings forward (with respect to the frame), and by means of a gear and rack it turns the rear elevation rudder for ascent. If there is a sudden tilt down to one side the pendulum turns a tube T , fitted with bevel gearing, in such a manner that the side ailerons are moved inversely for correction of the tilt.

The P. R. Torbrand automatic control, patented on September 20th, 1910 (U. S. patent No. 970,974), is similar in many respects to the Means device. The pendulum P (Fig. 6) controls the lateral and longitudinal equilibrium by movement of ailerons and rudders. A lever L , when moved forward and back, gives voluntary control of the elevation rudder E and con-

trols the rear direction rudder R by side-to-side motion. There is no voluntary control of the lateral equilibrium, however, in this device, the pendulum alone being relied upon to keep the machine on an even keel transversely.

The well-known automatic control of the Wrights, patented both here and abroad, relies upon the movement of a pendulum mechanism caused by the lateral tilting of the aeroplane, which actuates a valve controlling the admission of compressed air to a cylinder, thus moving a piston and by suitable connections operating the warping of the planes and the rudder.

will cause great internal stress in the framework supporting it, and will only slightly affect the equilibrium, while it is certain that turning in any direction would be practically impossible if the gyroscope is strong enough.

But if a light gyroscopic apparatus is installed, capable only of operation of the controls by its motion of precession, there is great possibility of an absolutely automatic stability. The Marmonnier and Regnard gyroscopes are devices of this sort. Up to the present, however, such devices have been found very delicate and difficult to handle, and the refinement re-

quired in their construction is great and expensive, while in any very turbulent condition of the air the action becomes so complicated that the apparatus merely jerks the rudders in every conceivable direction.

A very simple and effective means of using gyroscopic force, however, is that described in the patent of A. M. Herring. The aeroplane is equipped with two propellers rotating in opposite directions as on the Wright machine. The

propeller shafts are mounted on ball and socket joints in such fashion that they can swing in a horizontal plane without affecting the drive from the motor shafts. The propeller shafts are prevented from swinging in vertical planes. When the aeroplane in flight tilts up or down, longitudinally, the propeller shafts, due to gyroscopic action, will either swing toward each other or away from each other. This movement is communicated to the elevation rudder by suitable means and causes it to right the machine.

III.

The employment of auxiliary planes or vanes that are designed to fly out in the air stream under all conditions of equilibrium of the aeroplane is a very simple method of attaining automatic stability, and one that promises much, as soon as the actual nature of the stream flow about an aeroplane is fully determined.

Capt. Etévé recently installed a device of this kind on his French Wright machine. A light hinged vane was permitted to flap freely in the air stream at the rear of the aeroplane, and was connected to the elevation rudder at the front by a lever system. Whenever the aeroplane tilted longitudinally the vane caused the rudder to move in such a manner that the machine was righted.

The Wright automatic stability patent makes use of a vane of this kind for longitudinal equilibrium, the movement of the vane actuating a valve controlling the compressed air supply to a cylinder, the piston of which operates the elevation rudder.

IV.

Elasticity of structure of the planes, as on the Paulhan and Bréguet, gives a certain degree of stability. A sudden downward gust on one side, for example, due to the great flexibility and "give" of the plane, will increase the angle of incidence on that side, thus momentarily increasing the lift and counteracting the depressing effect of the gust.

On the Bréguet the rear cruciform tail is mounted and held by light springs. A sudden upward gust on the tail will thus cause it to give way a little and be turned in such a manner that the increase of air pressure on the upper horizontal face will force it down, counteracting the upward gust. This is an admirable provision, and gives a remarkable degree of stability.

V.

The "box kite" structure of the old Voisin type and the consequent hold it had on the air is well known, as is also the upturned wing ends of the Pischoff, Etrich and Warchalowsky aeroplanes and the manner in which they tend to automatically hold the machine on an even keel. The Dunne principle of a V-shaped

8. An early helicopter patent. 9. An auxiliary plane system for automatic balance. 10. Pivoted plane and propeller system patented by S. S. Morrison. 11. The E. P. Johnston device for automatic stability.

The Pressey automatic control (see Fig. 1) is about the simplest and most effective yet devised. In this system very little weight is added, since the pendulum weight S consists of the aviator seated in a swinging seat. Any sudden tilt of the machine causes him to swing in such manner with reference to the planes PP that the usual rudder or aileron operation at once takes place. In addition provision is made for "locking" the seat, thus enabling voluntary control of ascent or descent. AA are the ailerons, EE the elevation rudders and R the direction rudder.

II.

The precession action of the gyroscope offers an excellent solution to the problem of automatic equilibrium, but its action is so complicated that if its operation is not thoroughly understood there is likely to be great confusion in the preservation of the equilibrium. When any disturbance occurs, there is little doubt that a gyroscope solidly fixed to an aeroplane

Figs. 12, 13, and 14.—Showing the manner in which a pendulum preserves stability.

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Octave Chanute

(Continued from page 468.)

Mr. Chanute forwarded a quantity of aeronautic literature, visited the camp at Kitty Hawk, North Carolina, where Wilbur Wright and his brother Orville made their first glider experiments, and continued their steadfast mentor till they had transformed the glider into a true dynamic aeroplane.

Similar counsel and friendly sympathy was extended to some of the pioneer aeroplanists in Europe, who likewise succeeded ere long in powering the Chanute glider and transforming it into a successful dynamic biplane. In fact during the first decade of the twentieth century the development of the light gasoline engine had advanced so far that every clever mechanic who had money enough to procure a good one, of the Antoinette pattern, for example, could power a Chanute biplane and fly in fair weather. This was well shown by several brisk young men in France, and in particular by the famous aeronaut, Santos-Dumont, who, without special preliminary training in aviation, and while others were cautiously studying safe methods, suddenly bolted into the air on a crude biplane, and navigated over the heads of his astonished friends by sheer audacity and awkwardness, but ably seconded by his marvelous Antoinette motor.

One naturally inquires why Mr. Chanute did not achieve that easy renown. The reason was simply that when a light motor was first available he had passed three score and ten. He was now too old to ride an experimental aeroplane and too scrupulous to invite any one else to take such a risk. He had completed his important pioneer work and was serenely watching the younger generation of men as they appeared on the scene one by one, then by scores, to enjoy the fruits of his labor and that of his confrères, Lillenthal, Pilcher, Langley and others who had helped to prepare the way for final success.

Before his death on Thanksgiving Day, 1910, Mr. Chanute had seen his most sanguine dreams more than realized. Flyers were traveling from city to city at more than railway speed; sweeping over vast stretches of water and unknown territory, guided through fog and tempest by the simple mariners' compass; soaring like eagles above the rain clouds and in regions white with frost; racing over the Alps; contending in great tournaments; maneuvering with armies as a serious adjunct of the great military establishments of the world. He did not live to see an aeroplane rise differently from land or water, nor to see a dozen passengers in one machine, nor an aviator of less than a year's training fly without pause from London to Paris, through fair and foul weather, at more than a mile per minute; but these things he could easily anticipate, and much more that still remains to be accomplished.

One favorite dream of his that still remains unrealized is the achievement of soaring flight. He was convinced that the great vultures, gulls and powerful birds of prey can in favorable weather ride the wind for hours without wing-beat or the expenditure of propulsive power. Indeed, one incentive to his gliding experiments was the hope to promote the art of human soaring. And one of his latest papers published in *Aeronautics*, two years before his death, demonstrated the feasibility of soaring in a wind having an upward trend of three to four feet per second. He wished to have young men take up gliding as a sport in those localities favorable to such art, particularly where a steady breeze flows up a sandy slope by the sea, hoping that they might eventually acquire something of the art of the condor and the albatross. Perhaps ere long that dream, too, may be realized, when the talented volplanists of the present hour turn from their dynamic machines for a vacation's contest with the vultures and the gulls.

The foregoing is but a partial glimpse of Mr. Chanute's ceaseless activity in aviation during the last twenty years of his life. His most arduous, and next to the glider experiments, perhaps his most effective efforts were exerted to

stimulate or assist others. He wrote substantial and numerous letters to those in need of his valuable counsel; in his varied travels at home and abroad he would visit and personally cultivate those who were earnestly studying his favorite science. Unostentatiously and unknown to the world at large, he gave financial aid to several hard working observers or experimentalists in various countries. Often fifteen thousand dollars, in one form or other, was thus given to the promotion of aviation without prospect of return, not to mention many times that amount of his valuable professional time. Thus by virtue of his own inventions and researches, and by virtue of his most generous and sympathetic assistance of all earnest votaries of the art, he has doubly merited the title sometimes applied to him by his countrymen—"The Father of Aviation."

Unhappily for those who appreciated his work, no very adequate or formal recognition of his earnest and important labors in aeronautics was made by his countrymen during his lifetime. This perhaps is due to the fact that he was taken from their midst so shortly after the science of mechanical flight began to assume great value in the general estimation. It is to be hoped, however, that ere long his countrymen will establish a suitable memorial of his long devotion and fine achievements in a science of such fascinating interest and untold possibilities for humanity.

Automatic Stability of Aeroplanes

(Continued from page 471.)

structure with the line joining the tips of any pair of wings passing behind the center of gravity, and the angle of incidence gradually decreasing until at the tips it is decidedly negative, is one that probably holds a very good key to the solution of the problem of automatic stability.

The common dihedral angle of the two halves of the main plane to each other and of the main plane to the keel or tail as excellently exemplified on the Antoinette, also gives a measure of automatic stability that is now widely understood.

VI.

Sir Hiram Maxim, on October 25th, 1889, in England, patented a device whereby the difference in the pressure of the atmosphere on the roof of a box causes a movement not unlike that of the diaphragm of an aneroid barometer, which is communicated by a delicate mechanism to the motor feed and by the regulation of the motor keeps the altitude practically constant.

On December 31st, 1895, E. J. Pennington patented in England a still more interesting device in which the electric motor and worm gear drive of the elevation rudder is controlled by means of the index finger of a barometer so as to maintain the aerial vessel at a predetermined altitude. In addition the motor and worm gear operating the rudder for direction is controlled by the movement of a compass needle which, by means of electric contacts, causes the motor to turn the rudder so as to keep the machine on a steady course.

Such devices are highly ingenious, but their practical worth is still to be determined.

Earle Ovington's Blériot

MR. EARLE OVINGTON, who is flying almost every fine day in Long Island, has brought to this country the first of the new 1911, 70 horse-power Blériots. The machine is fitted with a new seven-cylinder Gnome motor, the first of which was made by the Gnome Company for Blériot's passenger machine, and the second for Farman. Mr. Ovington's Blériot has the new inverse curve tail, which will characterize all the 1911 single-place Blériot monoplanes.

Mr. Ovington is an engineer, and has had special features incorporated, principally to strengthen the construction. Instead of the four steel straps under the wings, he has had six fitted. Two extra main spars run the whole length of the wings. There are just twice as many ribs as in the wings on the ordinary 50-horse-power Blériots. Every control wire on the machine is in dupli-

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