YOU CAN FLY

by

CAPT. D. M. K. MARENDAZ

"EVERY MAN HIS OWN PILOT."

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THIS BOOK IS DEDICATED TO THE PIONEERS OF FLIGHT IN ALL COUNTRIES OF THE WORLD WHO GAVE SO MUCH THAT YOU MIGHT FLY.

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By

CAPTAIN D. M. K. MARENDAZ

A PILOT OF THE ROYAL FLYING CORPS IN THE GREAT WAR, 1914-1918.

DIRECTOR OF GREAT BRITAIN'S FIRST POST-WAR PROVINCIAL FLYING SCHOOL.

ONE OF GREAT BRITAIN'S FIRST PRIVATE OWNERS OF AIRCRAFT.

FOUNDER, DIRECTOR AND GENERAL MANAGER OF THE BEDFORD SCHOOL OF FLYING.

DESIGNER AND CONSTRUCTOR OF MARENDAZ TRAINER AND OTHER AIRCRAFT.

DESIGNER AND PATENTEE OF MARENDAZ FLAPS.

The Illustrations in this Book are drawn from the Ideas and Sketches of the Author.

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CHAPTER ONE

BRIEF HISTORY OF FLYING.

To you who are interested in becoming Pilots or at least acquainted with the manner in which aircraft are flown, it is as well to ponder upon the fact that, until recently, not one of the instructions, nor any of the knowledge now imparted to you in this book, was available to mankind.

Alongside this ignorance of the art of flying went an almost complete absence of knowledge of aerodynamics; that is, of the functions and way in which various parts of an aircraft behaved in this entirely new element—air. Indeed, it was not known how or why an aeroplane could fly.

In addition to these two great difficulties, there was another equally as great, namely, the designing and construction of the early machines. In the first place there were no such things as aero engines, there was not even a reliable internal combustion engine. Whereas to-day it is common for engines to develop 1 h.p. for every pound in weight, or even less, such internal combustion engines as did exist weighed as much as 40 lbs. per horse-power. The effect of these handicaps can hardly be appreciated.

So far as the structure of the aeroplane itself is concerned, the materials used were of necessity the lightest possible consistent with strength. On this point there were no available data from any of the physical laboratories of the world, such as exists to-day, or any kindred industry that was of much assistance.

Generally speaking, the basis of the very early machines was bamboo and cloth, braced and supported by piano wire. It was said of one notable machine that the piano wire and bracing struts were so numerous that if one put a canary into it, it could never find its way out! Other attempts utilised ash and spruce and, despite all the world's research and vast knowledge of aircraft materials, it is a notable fact that, strength for weight, spruce still remains superior to any material known to us.

In the midst of these somewhat primitive constructive efforts there came like a bombshell an all-steel machine equipped with a radial engine, conceived, designed and built by Robert Esnault Pelterie, a Frenchman, of whom little of the credit due to him is heard and who unfortunately lost his life through his imperfect knowledge of the art of flying.

Many and varied were the methods employed by which the Pilot could control the machine. First of all, lateral control (in the rolling plane) was obtained by the warping of the wings. That is to say, the rear portion of the outer part of the wing was bent downwards. This, of course, brought major problems of construction and design, for in addition to the wing being strong enough to support the machine, it had also to be flexible! In some cases the Pilot operated this warping by a half hoop to which his back was secured when in the Pilot's seat. By moving his body to the right, the right wing dipped and the left one rose. All this is now

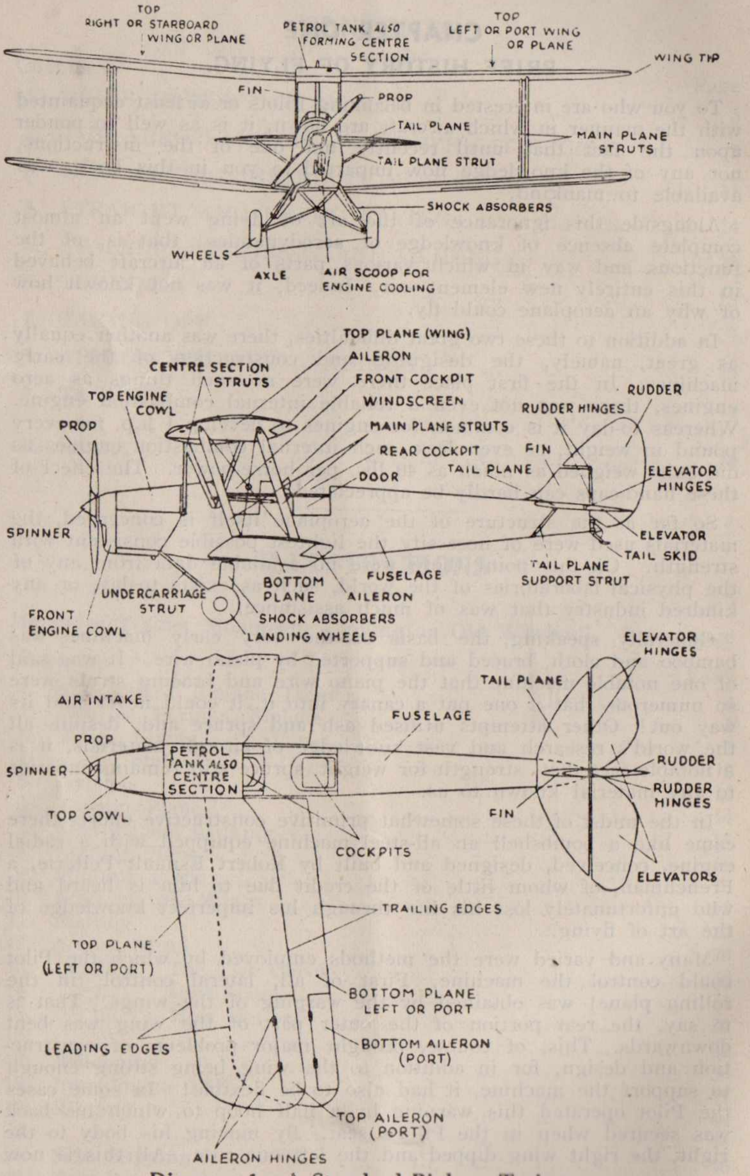


Diagram 1.—A Standard Biplane Trainer.

replaced by small hinged surfaces, known as ailerons, allowing the main part of the wings to be constructed rigidly, and they are operated by movement of a "stick" in the centre of the cockpit, to the right hand side or to the left.

The movement of the machine from a straight path to the right or left was sometimes operated by two levers, one on the right hand side of the Pilot and one on the left. Pulling either lever towards him resulted in moving the rudder in one direction or another, and therefore deviating the machine from a straight course either to the right or to the left. It was not always that these rudders were placed at the tail as is universal to-day; some machines had rudders situated at the outer extremities of the mainplanes or wings.

To move the aircraft upwards or downwards an elevator was employed. This was carried forward of the mainplanes by out-

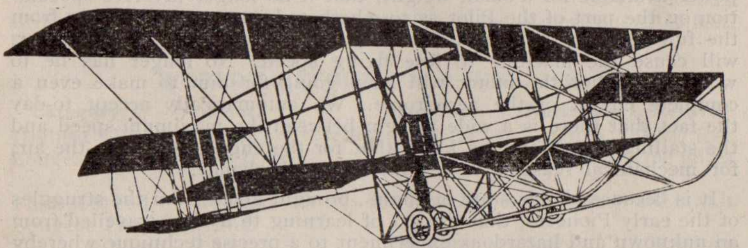


Diagram 2.—Maurice Farman Longhorn.

riggers. (See illustration of Maurice Farman Longhorn above.) Putting the elevator in this forward position was thought to be essential to keep the machine on an even keel. When a machine was built with the elevator at the rear, incorporated in the tail, it was called headless, and engineers at that time foretold that the only result would be inability of the machine to fly at all, or, if it did, an instant nose dive to the ground! The means whereby the Pilot controlled the elevator were numerous.

Inherent stability, which we take for granted in our machines, was unknown. Even in 1916, when the author learnt to fly, our elementary trainers were so unstable and unairworthy that we had to fly in the early morning between 4 and 7 o'clock, and late in the evening between 6 and 10 o'clock. Between these times, when the sun was hottest and produced what we call "bumps," our trainers were to all intents and purposes uncontrollable. There were no side surfaces to prevent side-slipping into the ground if one wing went down, there was no dihedral angle automatically to assist it level again, and there were no parachutes! Study the illustration of the Maurice Farman Longhorn closely and compare with the illustration of your trainer.

Gradually, by a seemingly slow and cumbrous process, involving the loss of many valuable lives, we have arrived at a universally adopted means for controlling an aeroplane so far as the necessary components are concerned, namely, elevator, rudder and ailerons. There is no diversity as to the position in which they are situated on the machine. So much experience has been gained that we can calculate the exact areas required and know precisely how much movement is needed.

Alongside the constructional standardisation has been adopted a standard means by which the Pilot may operate the control surfaces. The stick, by movement to and from the Pilot, works the elevator. The same stick, when moved from side to side, controls the ailerons. The rudder is controlled by a rudder bar pivoted at its centre, and upon each outer extremity the Pilot places his right and left foot respectively. If he moves his right foot forward, the rudder bar is moved round the pivot, bringing the rudder to the right and vice versa.

Improvements in engineering in the lapse of years have resulted in the total weight of the aircraft being so reduced by the great power available for a small weight, that it no longer involves speculation on the part of the Pilot as to whether, bringing the throttle from the full open position back to a position giving three-quarters power, will cause the machine to lose flying speed. No longer has he to wonder whether the motor will keep going for him to make even a complete circuit of the aerodrome. We automatically accept to-day the fact that there is a wide margin between the maximum speed and the stalling speed, and we know that for the engine to fail in the air, for mechanical reasons, is a million to one chance.

It is because of this state of affairs, brought about from the struggles of the early Pioneers, that the art of learning to fly has travelled from an unknown and hazardous experiment to a precise technique whereby it is safe to say that any man or woman of average ability can learn to fly and become a Pilot.

The proficiency of the Pilot and his dexterity, it is true, must always remain a matter of temperament and character. Some people must for ever remain more methodical, more careful, more thoughtful than others, but one and all can be taught to fly, albeit that they might eventually become good Pilots, indifferent Pilots or even bad Pilots, and it is the fool-proofness and safety of the present day machines that make it possible for the last even to fly at all.

It is not the purpose of this book to dwell upon the rights and wrongs of the use to which the efforts and knowledge so hardly gained by these Pioneers has been put by mankind in warfare. It is worthy of note, however, that although we may date the first flight in an aeroplane ever made by man as 1903, at the outbreak of the world war, 1914-1918, so little attention or thought had been given to the use of flying machines for fighting in the air, for bombing or kindred uses, that the military commanders, desirous of pressing aviation into the conduct of the war, had to equip the observer with an ordinary sporting shot gun!

The Pioneers of Flying visualised, albeit in a limited manner, the great advantages to the human race that would arise from a means of locomotion that did not depend upon the expensive construction or the length of time involved in the making and laying of macadam roads, railways, harbours and dry docks and all the attendant necessities that went with the older forms of locomotion.

The following World's Records as at June, 1910, and June, 1939, strikingly illustrate and reflect the progress in Flying. As a Pilot you will realise that not only do machines go higher and faster but they have been made so that you can control them at these enhanced heights and colossal speeds—achievements of parallel greatness in a short space of less than 30 years.

WORLD'S RECORDS, 23rd JUNE, 1910.

Category.	Pilot.	Machine.	Nationality.	Record.
Highest Altitude.	Paulhan	Farman Biplane	French	4,124 feet.
Longest Flight.	Henri Farman	,,	,,	145 miles.
Fastest Speed.	Christiaens	,,	,,	47 m.p.h.
Longest Time in Air	Henri Farman	,,	,,	4 hours 17 minutes 53-1/5 seconds.
British Height Record.	H. A. Drexel	Bleriot Monoplane.	American	1,100 feet.

WORLD'S RECORDS, 23rd JUNE, 1939.

Category.	Pilot.	Machine.	Nationality.	Record.
Highest Altitude	Adam	Bristol	British	57,937 feet.
Longest Flight	Kellett and others	Vickers	British	7,162 miles.
Fastest Speed	Wendel	Messerschmitt	German	469 m.p.h.
Longest Time in Air (without refuelling)	Tondi and others	Italian	Italy	72 hours.

CHAPTER TWO

THE AEROPLANE: HOW AND WHY IT FLIES.

Present day machines fall into two broad categories, the monoplane and the biplane. The monoplane is the only type used for commercial and war purposes. It is readily distinguished from the biplane in that it has one pair of wings or planes; that is to say, it has one wing on each side of the main body (fuselage) of the aircraft.

The biplane is a machine that has two pairs of wings situated one above the other, the upper wing being approximately five feet higher in a trainer machine than the lower wing.

For elementary training, the British Empire and many countries still employ the biplane.

All aeroplanes are heavier than air and in view of this it will be helpful to us in our flying lesssons to understand how and why they fly.

Newton discovered for us that the earth's gravity attracted the apple to it, and gravity tries to pull the aeroplane down to earth all the time it is flying. But this is not the only influence we have to overcome. The air around us, although we cannot see it, has density and weight, thereby setting up a resistance to all objects or bodies that we may try to move through it. By virtue of the fact that it is not as dense as water, we have to pay attention when designing an aircraft to its total weight in relation to the supporting surfaces, which are the wings. As the machine moves through the air the resistance caused has to be overcome, so that much of the power of the engine is expended in counteracting this, which is technically referred to as drag. The greater the area, obviously the greater this resistance, which acts as a brake. Hence its name " drag."

The higher the speed at which we force an object through the air, the greater, too, is the amount of drag, and this is the reason for every machine, no matter how large its horse-power, nor how small its wing area, having a maximum speed.

So before we can take a machine off the ground into the air, the engine has to develop sufficient power to overcome the drag and all the time the machine is in the air a large proportion of the engine power still has to be expended for this purpose, and some to combat the earth's gravity.

In order to cut down the drag to a minimum, the shape or section of the wings is made in a streamline form—which really means that the shape is such that it causes the least resistance possible whilst travelling through the air.

It will be apparent that if we want to move through the air a piece of wood 12-in. square by 2-in. thick, less resistance will be caused if we tow or push it flatwise on. The area presented thus, to the density of the air is 12-in. long by 2-in. deep, totalling 24 square inches. If, instead, we try to impel the same piece of wood through the air flatwise, then, 12-in. by 12-in., totalling 144 square inches, will be the area meeting the air, head on. So we see the very great importance of minimising what is called head resistance.

However, merely reducing head resistance to a minimum and overcoming the drag is not sufficient to enable us to fly. In addition the machine must be lifted into the air.

This is where our streamline form comes in to help us in a second way. Its shape is such that, as the wing ploughs through the air, the leading portion throws the air upwards. Of course, the weight of the air above it immediately tries to flatten it out and it does actually do so. It bends it back again, but before it bends it back sufficiently to touch the upper portion of the wing, the wing has travelled onwards, and for this distance there has been no air in contact with the top of it. This absence of air we all know is termed a vacuum, and we know that a vacuum causes a suction or pull. If we stand near the edge of a platform when an express train is going through, we can see and feel our clothing being drawn in towards the train, and when the end of the train has passed us we are definitely tended to be drawn in the direction it was travelling. The air drawn by the train, rushing past us, created a partial vacuum.

It is this vacuum that gives us lift and so it is the upper surface of the wing which supports the machine. (See Diagrams 3 and 4 on page 9.)

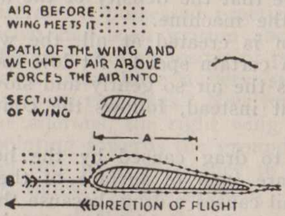


Diagram 3.—The Wing Flying.

At the nose of the wing marked by an arrow (B) the air is divided by the action of the nose being pushed through the air by engine and propeller.

The shape of the nose is such that the layer of air forced upwards shoots right off the top surface of the wing and between dotted lines (A) no air stream surrounds the wing. By the time the wing has travelled the distance A the air has been able to make contact with the top surface. This empty space is a vacuum which supports the aircraft; for so long as the machine flies this action is continuous, although A may sometimes shorten and sometimes lengthen slightly.

Diagram 4.—The Wing Stalled.

Here is the same wing. But now the stick has been pulled back and the elevator has gone down, forcing the front of the machine up. The wing section has left its normal horizontal axis for level flying and the angle it has gone through (technically termed angle of attack) is, say, 40 degrees. At this angle we will assume our trainer will stall. Different types of machines stall at different angles; again the angle will vary as to the amount of throttle opening, or if we are gliding, as a little thought will prove; but we must understand first, for simplicity, what occurs here in a machine at stalling speed.

The diagram shows the airflow around a stalled wing. The angle of the wing is so great that the air that shoots upwards at the nose can no longer be pressed on to the wing two-thirds backwards from the leading edge. Instead of the closed cavity which formed a vacuum we now see a series of swirls. All "lift" has gone and the machine ceases to fly.

A common error is instilled in the minds of many people with regard to this. They believe that the density of the air on the underside of the wing supports the machine.

Before the vacuum is created at all, the wing has to be moved through the air at a certain speed. At low speeds the leading edge of the wing displaces the air so gently and slowly that the air is not thrown upwards, but instead, follows the contour of the streamline form.

Now in addition to drag caused by the head resistance of the machine, every square inch of surface of the wings and fuselage, undercarriage and tail causes a drag, because the air is stationary and pressing against the machine, which is a moving body that wants to get on. So then, a machine rises into the air when the engine has turned the propeller sufficiently fast to draw the machine at a speed where the lift exerts a greater force than the total drag.

If the machine is in the air and the speed falls below this point, then drag takes control, the machine ceases to fly and commences to fall. This condition is known as stalling.

Having got to the stage where the machine is prepared to rise from the ground, we want to be able to make it go where we wish; in other words, we want to be able to control it.

All modern machines are controlled by means of hinged surfaces. There are three of them. The rudder, the elevator and the ailerons.

The rudder and the elevator displace or move the whole machine from the direction or altitude in which it was flying when we moved them. The ailerons actuate the wings and their purpose is to raise one wing above the other. If the machine is flying on a horizontal keel and we bring the ailerons into operation, one wing will rise above the other so that the machine no longer flies on a horizontal keel but points at an angle to the earth.

Both the rudder and the elevator have big things to do in relation to their small size. A rudder having an area of only two or three times the size of a pocket handkerchief has to force the machine from the direction in which it was flying, to point in another direction when it is moved. The same applies to the elevator except that, instead of moving the machine in a new horizontal direction, it moves it in a new direction, up and down. As it is desirable to have such small areas to move such a large mass of machine, we place them backwards as far as is practically permissible from the main mass, which is, of course, engine, mainplanes, etc. Putting them so far away from the work they have to do is similar to applying a crowbar or lever to move a large stone.

When we look sideways at an aeroplane we see a long body, and if it is our trainer biplane that we look at, the front of the body which accommodates the engine is about two feet deep. Towards the middle it becomes much deeper and then narrows down at the tail. On the top of the body or fuselage we observe a fin, which is an area rising above the fuselage but with its long surface presented towards us. The whole of the side of this body and fin that we can see is known as side surface or side area.

A glance at Diagram 2 on page 5 of a Maurice Farman biplane used for elementary training up to 1917, will indicate that, in common with all other early aircraft, it possessed practically no side surface. We also know from what has been written above that all surfaces cause drag. Clearly therefore the enclosing of present day fuselages so as to create side area must have a very strong reason for its inevitable presence in modern machines. Now imagine you are in the air and, by moving the ailerons, the right wing has risen above the left, the left wing is pointing towards the ground, then the side area of the fuselage and fin sets up a resistance to the machine falling sideways (side-slipping) quickly to the ground.

In our flying lessons we shall see that by putting on the correct amount of rudder and making the banked position into a turn, we can in any case prevent involuntary side-slipping, but the presence of the large side area makes up for slight inaccuracies in the amount of bank or rudder. In the early machines like the Farman it was the absence of side surfaces that often caused them to side-slip into the ground so quickly and easily that the Pilot had no chancce to prevent it.

Now if we examine the construction of a biplane, we find that there is approximately double the wing area as compared with a monoplane. In addition, the struts or props that have to be fitted to keep the two planes one above the other, as well as the wires necessary to brace and keep in place the whole construction, must cause more drag than a single pair of wings without such impedimenta, and herein lies the reason for the monoplane superseding it.

CHAPTER THREE

HOW FLYING INSTRUCTION IS GIVEN.

There have been authenticated instances of people in recent years taking machines into the air without any flying instruction other than what they have gleaned of the theory of flying, just as there are many people who have taught themselves to drive a motor car.

Despite this fact it is wise to take advantage of the experience of others, and when it is a case of applying theory, as learning to fly, the fullest advantage of the tremendous accumulated practical experience cannot be obtained without the presence of an Instructor to advise and correct.

Instructors throughout the world are men and women who are authorised by the Governments of the country in which they live as being proficient in the art of flying and able to impart that knowledge.

In addition to being capable Pilots these people have to pass a specialised Instructor's Course, which takes time and costs money. In the first place, the Instructor-to-be passes many hours in the air with Instructors of long experience who correct their faults in flying, until the would-be Instructor has reached the proficiency in which he can carry out all evolutions and recover the machine from all possible situations with the utmost skill and proficiency. The Instructor has to tell his pupils whilst in the air what he is going to do and how the pupil should do it. This applies to all the sequences of flying instruction, the elementary ones being covered in Chapters 4 to 9.

It is highly desirable that each and every instruction shall be standardised so that the highest standard of flying is available to every would-be Pilot. This instruction and advice given in the air is known as "Patter" and whilst it embodies all the information that long years of experience have found to be necessary, it also excludes much which at first glance might be considered beneficial. Nevertheless it is excluded because experience has shown that it is confusing to some people. From time to time this patter is revised and brought up to date.

To achieve this standardisation it is necessary that there shall be one overriding authority, and to that end all patter utilised throughout the British Empire is issued and authorised by the Central Flying School of the Royal Air Force. It applies to civil schools when they are operating in peace time, as well as to military elementary training.

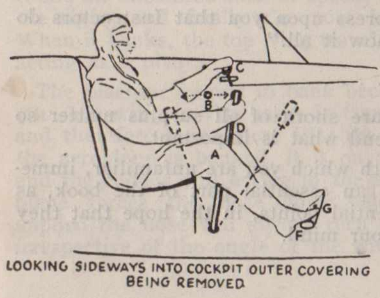
One of the first things that will impress you when you hear a machine started up is how it is possible to say anything that will be heard by anyone else in such a noise. You will wear a helmet and to the earpads of this helmet is fitted the receiving end of a telephone. Tubes hang down from each ear for a length of 18-in., ending in their junction into a small metal pipe. When you get into the cockpit you plug this into a corresponding pipe. In front of you is a permanent fixed mouthpiece. The same equipment is fitted in the Instructor's cockpit and so you are able to talk to one another with reasonable facility.

Some Continental countries hold that it is confusing to the pupil, if he knows his theory, to have to execute the evolution and at the same time listen to the Instructor. So in place of the telephone they rely entirely, firstly on the pupil knowing just what he is going to do, and secondly on signs made by the Instructor with his hands, easily seen and recognised. If, for instance, the pupil is flying with his right wing low, the Instructor would hold his right hand palm upwards and give it an upward movement. Countries using this procedure include Germany and Holland. If there is something in this theory it will be all the more apparent that you should be perfectly conversant with the knowledge to be gained in this book, so rendering unnecessary repetition and continuous instruction from the Instructor.

In the early stages of a pupil's tuition the Instructor takes off and flies the machine to a safe height—say 600 to 1,000 feet. During this time the pupil should take an intelligent interest in what is happening and may gently hold the stick and keep his feet loosely on the rudder bar. In this way you learn the amount of movement necessary and the action required for taking off. At the desired height the pupil is told to take over and proceed with either of the lessons detailed in Chapters 4 to 6. At the end of that particular lesson the Instructor again takes over and lands.

Each lesson lasts about half an hour. This sounds a very short time but the concentration needed is fatiguing and although so long as you remain in the air you do not feel tired, once the pupil is out of the machine, this becomes apparent. Gradually this tiredness after a short flight disappears. You become used to the fresh air as automatic action takes the place of concentration.

Be sure **you** have heard distinctly what **your** Instructor says in the air. If you have not, tell him so. Maybe your helmet does not fit you well. Instructors do their job all day long, all the week long, and they sometimes get cross when they ask that you should do something and you proceed to take no notice or do something contrary.



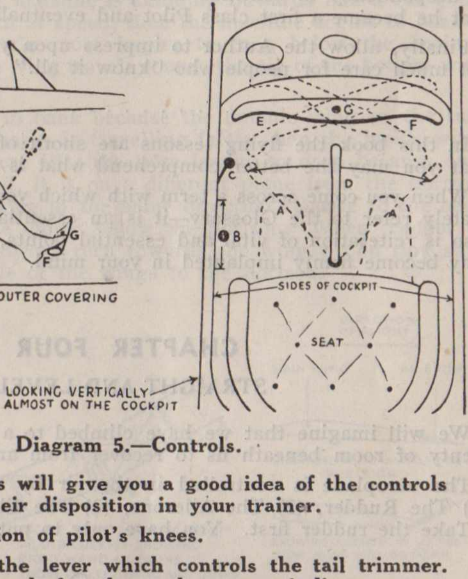


Diagram 5.—Controls.

These two sketches will give you a good idea of the controls and their disposition in your trainer.

A represents position of pilot's knees.

B is the knob of the lever which controls the tail trimmer. It moves fore and aft only as the arrows indicate.

C is the throttle which you operate with your left hand.

D is the stick. Looking at the right-hand sketch, when it is moved either side of the central or neutral position in which it is shown, it controls the ailerons. The arrows indicate this movement. To the right, the right wing goes down; to the left, the left wing goes down.

Looking at the left-hand sketch, the dotted lines indicate the fore and aft motion of the stick. Movement forward, nose down—bringing it to the rear (aft) and the nose goes up.

E and F represent the position of your feet on the rudder bar. The bar is pivoted at G. The dotted lines show its movement.

At times you will not be satisfied with your progress; your friends who commenced at the same time are getting along quicker. Do not become despondent, and do not worry, it will only make matters worse.

In the Training Schools for which the Author has been responsible the average time taken from first lesson to solo was 8 hours and 40 minutes. The pupils' ages ranged from 18 to 50 and their occupations from typists and farm workers to politicians and barristers.

The least apt took over 17 hours to get off solo. He was an insurance agent some 30 years of age, was encouraged through all stages of despondency to continue and persevere, with the ultimate result that he became a first class Pilot and eventually an Instructor.

Finally, allow the Author to impress upon you that Instructors do not much care for people who "know it all."

. . . .

In this book the flying lessons are shorn of all surplus matter so that you may the better comprehend what is important.

When you come across a term with which you are unfamiliar, immediately refer to the Glossary—it is an essential part of the book, as also is reiteration of vital and essential points, in the hope that they may become firmly implanted in your mind.

CHAPTER FOUR

STRAIGHT AND LEVEL.

We will imagine that we have climbed to a safe height and have plenty of room beneath us to recover from any false move.

The aeroplane is controlled in the air by three control surfaces: (1) The Rudder, (2) The Ailerons, (3) The Elevator.

Take the rudder first. You have only to put one foot very slightly

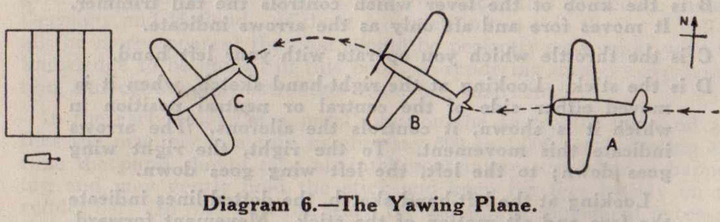


Diagram 6.—The Yawing Plane.

Imagine you are in a balloon, at 5,000 feet above the aerodrome. You watch a machine come into view 3,000 feet below you (Fig. A). You are looking vertically down on the machine. Suddenly it changes its course. From flying due west, it turns towards the north, then to the south. It has made two movements of the Yawing Plane.

forward for the nose to start slewing round the horizon. All movements of controls in the air are slight, except in aerobatics; and even then they are smooth and gentle, but firm and sure. Ease your right foot forward slightly—now centralise the rudder again. What happened? So long as your foot was forward the nose slewed round to the right slowly, and stopped, pointing in the new direction, as soon as you "took off the rudder" (centralised the rudder bar). This is a movement in the Yawing Plane. (Refer to diagram No. 6.) Now do it again and hold it. First the nose starts slewing round to the right along the horizon; then you notice a wind blowing on your left cheek, because the machine is skidding ouwards like a car going round an unbanked turn at speed, then the machine begins to bank to the right, and finally the nose begins to drop below the horizon. When it banks, the top wing travels round, the tip of the bottom wing acting as a pivot.

The machine begins to bank because the outside wing on the turn (the left wing in this case) is travelling faster than the inside wing, and therefore gains more lift; the nose begins to drop because once the aeroplane is banked, it is on a different plane from the horizon, and the rudder still acting in the same direction relative to the aeroplane, forces the nose down below the horizon. When rudder is applied the nose will always turn towards the wing tip on that side, irrespective of the angle of the wings to the horizon.

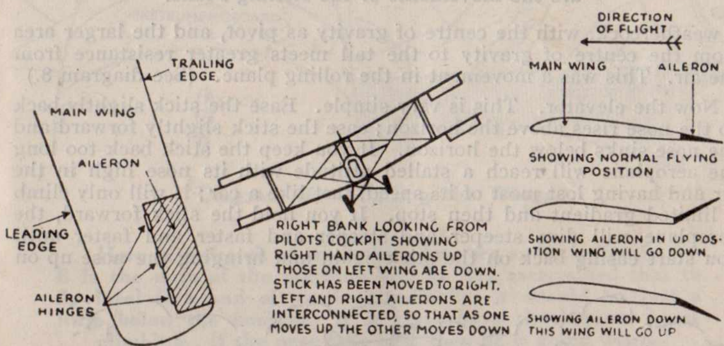


Diagram 7.—Ailerons.

Now the ailerons. We are flying level again, and you ease the stick slightly over to the right. What happens? The right aileron rises and the left aileron goes down. At the same time as the aeroplane banks to the right (left wing above the right wing), the nose at first slews slightly round to the left and up, the aeroplane side-slips to the right because you have not used any rudder to give it a turning movement, and then the nose falls because the lift behind the centre of gravity is greater than in front of it. The centre of gravity is just about in the front cockpit. When the aeroplane side-slips it acts like

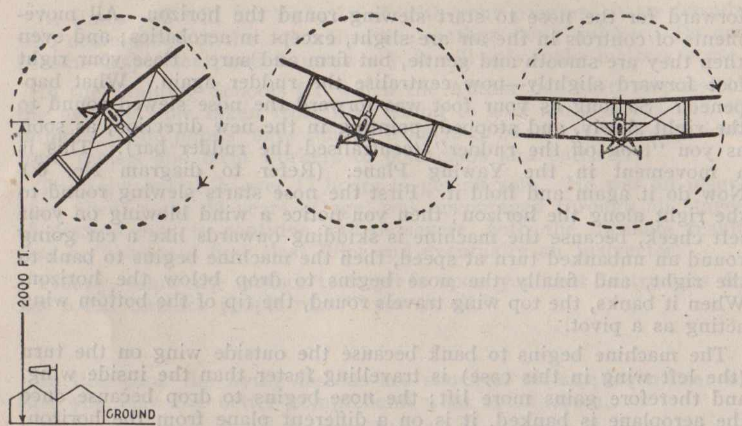


Diagram 8.—The Rolling Plane.

You are in a balloon 2,000 feet high, watching an aeroplane 2,000 feet high, flying towards you head on. It performs the evolutions indicated by the dotted circles as it flies. These are the movements of the Rolling Plane.

a weathercock, with the centre of gravity as pivot, and the larger area from the centre of gravity to the tail meets greater resistance from the air. This was a movement in the rolling plane. (See diagram 8.)

Now the elevator. This is very simple. Ease the stick slightly back so the nose rises above the horizon; ease the stick slightly forward and the nose sinks below the horizon. If you keep the stick back too long the aeroplane will reach a stalled attitude with its nose high in the air and having lost most of its speed, just like a car; it will only climb a limited gradient and then stop. If you hold the stick forward, the aeroplane will dive steeper and steeper and faster and faster until you start easing back on the stick again and bringing the nose up on

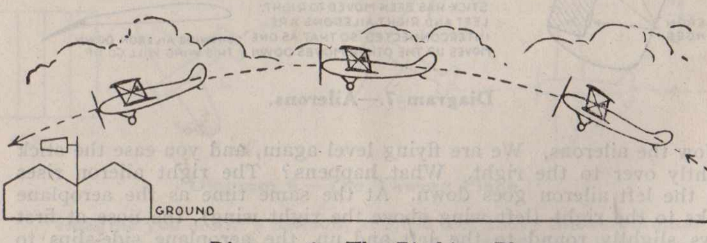


Diagram 9.—The Pitching Plane.

You are looking at the side of an aeroplane flying. On the right it is ascending. On the left, descending. These are the movements in the Pitching Plane.

to the horizon, when once again it will settle down to level flight. These are movements in the Pitching Plane illustrated in diagram 9.

Generally, the position of the throttle for normal cruising is about three-quarters of the way forward. The normal cruising speed varies for different types of machines. You will be told the correct speed for each machine. You climb off the aerodrome at full throttle, and then, when you are well clear of any possible obstruction, you ease back the throttle a quarter of the way. When you wish to lose height, you ease it back still further, so that the engine does not race and the speed of the aircraft is kept down to reasonable proportions. An aeroplane losing height has some of the peculiarities of a car going downhill.

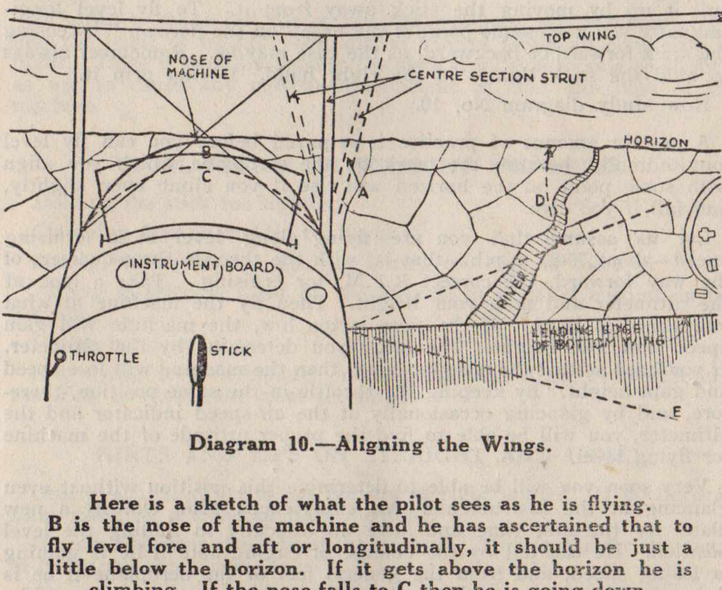


Diagram 10.—Aligning the Wings.

Here is a sketch of what the pilot sees as he is flying. B is the nose of the machine and he has ascertained that to fly level fore and aft or longitudinally, it should be just a little below the horizon. If it gets above the horizon he is climbing. If the nose falls to C then he is going down.

Now for flying level laterally. On the biplane trainer, if the centre section strut cuts the horizon at right angles, you know both wings are level. You may, too, find a spot on the strut to guide you instead of the nose for the fore and aft level. If the centre section strut no longer cuts the horizon at right angles, but assumes the position as dotted, then you are no longer level, but flying right wing low. If the trainer is a monoplane then, to be sure you are not flying one wing low, keep a close watch for the wing making angle D or E with the horizon, in this case the dotted lines being the leading edge new positions, according to right wing low or left wing low.

Before trying to fly straight and level take a look around you. Notice that your view is divided into two halves. That which is above the horizon and that which is below. The horizon stretches right round you. In fact it is a circle of which you are the centre. For this reason any point on it can be used as a guide to fly straight. Whatever your height above the earth, a line joining you to the horizon is roughly a tangent to the curve of the earth. The horizon can therefore be used as a guide to fly level, fore and aft. Similarly, by aligning the wings to the horizon, you can keep the plane flying level laterally.

You have realised by now that there are two planes in which to fly level—the lateral plane and the longitudinal plane. To fly level laterally you see that one wing is not lower than the other. If it is, pull it up by moving the stick away from it. To fly level longitudinally you keep some point of the nose "on the horizon " by easing the stick forward or backward, as the case may be. Remember always to hold the stick lightly in the right hand. Do not grip it.

Now study diagram No. 10.

A certain amount of practice is required before you can fly level longitudinally, because the mark on the aeroplane which you align with some point on the horizon will rise if you climb even slightly, and fall if you dive.

Let us assume that you are flying along level at a cruising speed—about 75-80 m.p.h.—that is, with the throttle three-quarters of the way forward, the correct R.P.M. for cruising. Take a look at the altimeter and note your height. Then fly the machine at what you think is level. If the nose is too low, the machine will gain speed and lose height. The latter you determine by the altimeter. If you have settled the nose too high, then the machine will lose speed and gain height. By keeping the throttle in the same position, therefore, and by glancing occasionally at the air-speed indicator and the altimeter, you will be able to find the proper attitude of the machine for flying level.

Very soon you will be able to determine this position without even glancing at the instruments. An experienced Pilot can fly a new plane for the first time and have no difficulty in finding the level position. He can tell by the change of engine note if he is gaining or losing speed, and from the general feel of the aeroplane if he is flying level. You must do so, by taking the horizon as your guide, as well as by " feel."

You want to learn to place as little reliance as possible on your instruments. Sometimes they go wrong, and probably in a moment of emergency you will have no time to look at them. So learn to fly your aeroplane by feel.

You know by now that the faster your speed the harder it is to move the controls and the less movement is necessary to get the required result. There is therefore a direct relationship between the feel of the controls and the speed of the aeroplane. This relationship is there without qualification for the ailerons, but the elevator and rudder, being behind the propellor, and therefore in its slip stream, are affected not only by the speed of the aeroplane, but also by whether the engine is on or off, or revving fast or slow. For this reason it is on the aileron control that the pilot depends for his " feel," in the main.

When the aeroplane is flying near its stalling speed, you will find that the aileron control is very "sloppy." You can literally move the stick from side to side of the cockpit with very little effect on the trim of the machine. When the aeroplane is flying fast, the aileron control has stiffened up, and you can only move the stick a little way before it takes effect. It feels quite firm. Here, then, is a perfectly accurate way for the pilot to determine at any time without reference to any of the instruments how near he is flying to the stalling point (the point at which the wings lose their lift and the aeroplane, as a result, drops out of control).

In order to make full use of this ready-to-hand safety measure, get into the habit of feeling your aileron control under all conditions of flight. Thise is done by moving the stick from side to side so slightly as not to cause any movement sufficient to alter the trim of the machine.

USUAL FAULTS ON STRAIGHT AND LEVEL.

Holding the stick too tightly.

Clamping feet on rudder too tightly.

Sitting too tensely or rigidly. Sitting too high or too low.

Failing to select a point on the aircraft to keep on a point on the horizon.

Flying one wing low.

Not flying level—climbing one second, and then overcorrecting, resulting in diving the next second.

HINTS AND TIPS ON STRAIGHT AND LEVEL.

Centre section struts to cut horizon at right angles. If no horizon, some point on a cloud or false horizon.

Do not lean over the side of the cockpit. This is usually the cause of flying one wing low.

Sit upright, turn your heard and **not** your body, as may be necessary for observation purposes.

After **every** movement of stick and of rudder do not forget to centralise.

Above all, before starting, arrange the cushions so that you are comfortable and that you are neither too high nor too low. You must " feel at home " and reach all controls without any movement of your body other than your limbs. You must be able to see out without altering your posture, which may mean the alteration of your pressure on the rudder bar as well as perhaps unconsciously taking the stick to one side, as you lean over to see, causing you to fly one wing low,

CHAPTER FIVE

STALLING, CLIMBING AND GLIDING.

The most important speed of an aeroplane, from the Pilot's point of view, is its stalling speed. This is because it is the speed at which the machine ceases to become air-borne and is therefore out of control. An aeroplane that has stalled always loses height (perhaps 200 or 300 feet) before sufficient speed has been regained for it to become controllable again. This height is lost very quickly indeed.

As the stalling speed is so vital, it is most necessary for a Pilot to be familiar with the symptoms that precede a stall so that he may avoid it.

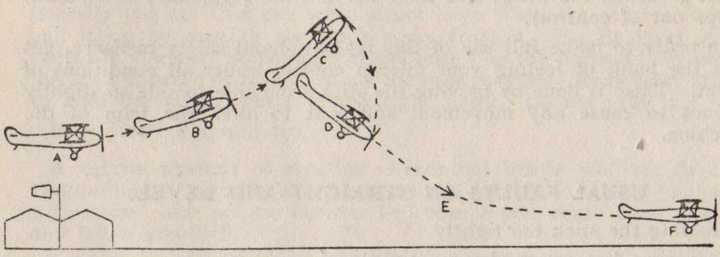


Diagram 11.—Stalling.

At the point A is a machine in level flight. The pilot decides to climb as at B; he tries to climb at too steep an angle (C) and the machine stalls. For very little or no forward movement the nose drops out of control and assumes the attitude D. The pilot, immediately the stall has occurred, centralises all controls except the stick fore and aft. Put this forward. The machine automatically dives to E, by which time it has gathered flying speed. Here the pilot again takes control by gently bringing the stick central fore and aft and the machine flies level again at F.

Much height is lost in this evolution, so do not forget the altitude you have been told to climb to before attempting it. Beware of accidental stalls, more especially at low altitude. If the ground were at D or E it would go badly with you.

The way to do this is simple. When you have gained at least 2,000 feet of height, and are flying straight and level, ease back the throttle as far as it will go, so that the engine is just ticking over, at the same time ease back the stick so that the nose is above the horizon. The machine will quickly lose speed; as it does so, feel your ailerons in the manner described in the previous chapter and notice how they become more and more sloppy. At the actual point of stall you are able to waggle the stick from side to side in the cockpit and it will have no effect. Another thing that happens as the speed drops is that the nose will appear to be becoming more and more heavy, so that, in order to keep it above the horizon, you will have to increase the pressure on the stick to keep it back. This you do at the same time as wagging it from side to side. At the point of the stall the machine appears to hang suspended and still. After what seems to be a complete pause in movement, the nose suddenly drops, in spite of the fact that your stick is as far back as it can be. This is because the point of stall has been reached and your controls are useless. To regain control, all you do is to ease the stick forward, and the machine will gather speed again and, with the increase in speed, your control will be regained. If you do not ease the stick forward, the natural action of the stalled machine dropping its nose will result in sufficient speed being regained for your elevator to take effect again, so that almost immediately this will result in a second stall.

Practice stalling sufficiently to get used to the feel of the controls before the point of stall is reached, so that you can avoid stalling involuntarily. The peculiar feeling of inanimate suspension which you get at the point of a deliberate stall will give you confidence once you become used to it. The distance of the nose above the horizon when the aeroplane stalls varies according to: (1) Speed at which you move the stick back; (2) the amount of throttle opening. Do not assume therefore that the aeroplane always stalls with the nose a certain distance above the horizon.

Be sure to keep the rudder bar central.

So much for stalling. The next thing to learn is how to climb. If we climb too steeply we stall, so this must be avoided.

Every kind of aeroplane has different climbing characteristics. But whatever your aeroplane, the best climbing speed is that which raises the aeroplane the greatest height in the shortest distance. Even two aeroplanes of the same type can have different climbing speeds, due to their being rigged differently. To determine the best climbing speed, fly straight and level, and then gently ease back the stick, at the same time opening the throttle, because you want more power from the engine for climbing. When the nose has risen a little way above the horizon, keep it there by correct adjustment of the stick. You will notice that the machine loses speed. You will see this by the A.S.I. and you will also hear the engine losing revs. As this happens, slightly move your stick from side to side, so as to get the feel of the aileron control. If the ailerons begin to feel sloppy, then you are trying to climb at too steep an angle for maximum efficiency, so ease the stick forward a trifle and continue to climb with the nose not quite so high above the horizon. The attitude of the machine at which you just feel a nice firm aileron control is the best climbing angle. When you have determined this, you can read off the speed from the A.S.I. and note the position of the nose above the horizon. Do not be misled by the fact that you can fly with the nose higher, without the machine stalling. You can certainly do this, but the machine is wallowing its way through the air, and is not climbing nearly so fast as when the nose is a little lower. The best climbing speed of your machine which cruises at 80 m.p.h. is somewhere in the region of 60 m.p.h. You will learn later on, this is particularly important when you are taking off, as you want to get as high as you can as quickly as possible. (This gives more chance to choose an area of ground in which to land in the event of sudden engine failure.) When you have reached a thousand feet or so, and you still want to go on climbing, then ease back the throttle a little, at the same time moving the stick slightly forward to avoid stalling, and so continuing the climb at slightly reduced power. Although the best climbing angle differs according to throttle opening, the best climbing speed, for all practical purposes, remains the same.

The next thing to learn is how to glide. Gliding is often erroneously described as flying with engine off. It is in fact throttled right down, so that it is idling at minimum revs. The engine would only be "Off" is you switch off; but this you do not touch. The reason it is wrongly described is no doubt due to the contrast of the roar of the engine when at cruising revs. and its silence when it is just ticking over on the glide. If the engine fails, then, of course, gliding is flying with engine off, but this is an involuntary procedure.

You have learnt that when climbing you are seeking to gain as much height as possible for horizontal distance covered. When gliding you seek to lose as little height as possible for horizontal distance covered. This generalisation, like every other one, is liable to modification, but in the main it is true. A Pilot throttles back his engine and glides in order to lose height, but he must be careful not to gain unnecessary speed and not to let it fall to stalling speed, so as to have the machine under full contol all the time.

In some respects gliding is similar to climbing. The gliding angle is the angle between the horizontal axis of the aircraft and the horizontal level of the earth. The Pilot maintains his gliding angle by keeping the nose in a set position in relation to the horizon, but instead of the nose of the machine being above the horizon as in climbing, it is below it. The best gliding speed of an aircraft is determined in a similar way to the best climbing speed.

In order to start a glide, throttle back as far as the throttle lever will go, and ease the nose down a similar distance **below** the horizon as it was above it for climbing. The speed of the aircraft will soon decrease and, if you have set the machine at the correct angle, it will settle down to a steady speed round about 60 m.p.h. If the nose is too high, the speed will drop further and you will feel your aileron control becoming "sloppy." So soon as this happens ease the stick forward; the nose will drop and speed will be regained. If you put the nose too far below the horizon, the speed will rise unduly. You will soon be able, by the noise or hum of your machine, to appreciate an increase or decrease of speed. The higher the speed the greater and more intense the hum.

You can also detect increasing speed by the stiffening of the controls as well as by a glance at the A.S.I. A steep glide is termed a dive, and is an inefficient way of losing height, in that the machine will traverse a comparatively short horizontal distance for height lost.

Be careful in gliding that you do not glide too slowly. You want to have a good margin of speed above the stalling speed to have full control. On windy days you must glide a little faster than usual (65 m.p.h.) in order to be certain of having control under sudden changes of air conditions. We need hardly say that an aeroplane will stall with engine off in just the same way as it does with engine on, if its Pilot allows it to lose flying speed by not keeping its nose far enough below the horizon.

HINTS AND TIPS.

The sensitiveness of controls when gliding is not so great as when flying level with engine on.

For the same amount of movement of the controls the effect is less when gliding than when flying with engine on.

Get used to the noise of the machine when gliding (with engine off) at 60 m.p.h. and be able to detect the rising note as the speed of the glide increases and vice versa.

Rely as soon as possible for checking up your gliding speed, on the hum of the machine and the "feel" of the controls. Remember that the A.S.I. has a lag, up and down, before you obtain an accurate reading, so the best indication of speed is your sense of hearing and touch.

USUAL FAULTS.

Once the machine has stalled forgetting to bring stick to central position (centralise it).

Failing to keep rudder bar central by exerting more pressure with one foot than another, resulting in the machine stalling with rudder on, thereby causing the aeroplane to go into a spin.

When climbing, a tendency to keep the nose too high.

Instead of keeping the machine in a steady climb, alternatively climbing too steeply or not steeply enough.

When gliding most people at first tend to keep the nose of the machine too low, resulting in gliding too fast, a very dangerous procedure near the ground when about to land. On the other hand, over-correction results in gliding too slowly, provoking a stall.

CHAPTER SIX

TURNING.

In order to appreciate the problems involved in the matter of turning an aeroplane, think for a moment of a motor car. If you take a turn on a flat level road too fast, there is a tendency for the car to skid outwards and overturn. Race tracks like Brooklands overcome this tendency by having "banked" turns. Some race tracks resemble the inside of a large saucer. Near the centre there is little or no slope; gradually the rim becomes steeper. This is what is known as the banking. The more acute the turn, the higher up on to the steeper part of the banking one has to drive. Supposing you drive too high up the banking for the acuteness of turn, then there will be a tendency for the car to slip inwards or down the slope. If you place the car too low on the banking for the same amount of turn, then the car of its own accord will try to go higher up—skidding outwards.

The same thing happens with an aeroplane, but instead of a Pilot flying along a track which is banked, he, by means of his aileron control, banks his aeroplane according to the acuteness of the turn he wishes to make.

The effects of the controls on a banked aeroplane is a little confusing at first. The golden rule is to remember that, relative to the aeroplane, they always produce the same effect. When you ease the stick back, whatever the position of the aeroplane relative to the horizon, the nose always makes an endeavour to catch its tail; when you put on left rudder (left foot forward) the nose will always turn towards the left wing tip, when you put on right rudder it will always try to turn towards the right wing tip. If you bear that in mind, you will have no difficulty in understanding the control movements for going into, holding, and coming out of turns.

Before trying a turn, think purely theoretically of the function of the elevator and the rudder under the two extremes of bank—full bank (wings at 90 degrees to the horizon), and no bank (wings parallel to the horizon). You know what happens in the latter case—ease the stick back and up goes the nose, put on rudder and the nose slews round the horizon towards the inside wing tip. Now, let us assume that the aeroplane is theoretically suspended in the sky, flying along with full bank on—that is, with its wings at 90 degrees to the horizon. What happens when you ease the stick back? The nose still tries to reach over your head and catch its tail; but because the wings are at right angles to the horizon the nose slews round the horizon. In other words, in a vertical or 90 degrees bank, the elevator has the same effect on the nose, relative to the horizon, as the rudder has when the aeroplane is flying level.

When you put rudder on in this fully banked position, the nose still tries to turn towards the wing tip, but because the wing is at right angles to the horizon the nose actually moves directly above or below the horizon, according to whether you put on top rudder (right foot forward in a left bank, left foot forward in a right bank), or bottom rudder (right foot forward in a right bank and left foot forward in a left bank). Intermediate angles of bank within these two limits call for compromise between elevator and rudder.

Bearing this in mind, let us try a gentle turn to the left. Ease the stick over to the left a little way. This immediately puts on left bank. At the same time put on left rudder to start the turn to the left. The left rudder will tend to drop the nose a little below the horizon, as well as slew it round, because the machine is on a tilted plane. You therefore counteract this by easing back the stick a little, which has the effect of lifting the nose up on to the horizon again; it has also the effect of helping to turn the machine. As the bank increases so the rudder loses its turning effect and assumes the role of elevator, and so the elevator loses its "elevating" effect and assumes the role of rudder. On this first turn we do not wish to do a steep bank. When you have got 20 degrees of bank on, adjust the stick so that the bank does not get any steeper. We say " adjust the stick " advisedly, because you might think that this is achieved by centralising the stick. In actual fact you will have to keep the stick a little over to the right, in order to prevent the bank increasing. This is because the right wing, the outside wing of the turn, is travelling faster than the inside wing. Consequently, if you were to centralise the stick in a turn, the bank would get steeper and steeper. You therefore always have to move it a little over the central position in order to " hold off " the bank increasing.

You must keep the nose just on the horizon in the same way as flying level. If you let it drop too low, the machine will gain speed and lose height. You pull it up again by adjustment of the elevator and rudder in the manner described above. If it gets too high the machine will lose speed, and you must bring it down again to the correct position on the horizon, just as you learned to do in your lesson on straight and level flying.

If you are turning too slowly for the amount of bank you have put on, you will feel the machine slipping inwards and a draught on your inside cheek, so put on a little more rudder. If you have put on too much rudder for the amount of bank you have put on, you will feel the machine skidding outwards and a draught on your outside cheek. It is better to have too much bank than too little, but you will soon be able to judge the correct amount.

When you want to come out of the turn, apply opposite bank and rudder together. You will find that more pressure is required on the controls coming out than when going into a turn. As you take off the bank, so you must adjust your rudder in order to be properly balanced all the while, otherwise the machine will skid or slip coming out of the turn, in just the same way as it will when in the turn, and the rudder is not correctly adjusted to the bank. Care must be taken to keep the nose on the same position on the horizon as before. To do this you will find you have to move the stick forward slightly.

Now try a steeper turn. By steeper we mean anything up to 45 degrees of bank. Until you are used to it you will imagine that you are doing a 90 degrees banked turn, when in reality you are doing one much less steep, because the unusual attitude of the machine on its side is misleading to you.

Now it is easier to understand. Once again assume that you are doing a turn with 90 degrees of bank. In actual fact you would not attempt this until you were well practised in less steep turns. But when your machine has 90 degrees of bank on, you can follow that the rudder becomes the elevator completely and the elevator becomes the rudder. In other words, the only way to adjust the position of the nose on the horizon is by altering the rudder, and the only way to adjust your bank is by means of the elevator. When in this position you can easily understand the meaning of the terms " top and bottom " rudder, which are used when referring to rudder movements during turns..

Because the effective wing area, and therefore the amount of lift, is less when the machine is banked it is most important to remember that the stalling speed of an aeroplane increases with the amount of bank used in a turn. The stalling speed of an aeroplane flying level may be 50 m.p.h., but when it is in a 60 degrees banked turn it is probably about 75 m.p.h. For **this reason when you do a steeper turn, always use more throttle.**

When practising turns, do not get into the habit of always turning in the same direction. You may find, if you are right-handed it is easier to do turns to the left, and to do them to the right requires much more concentration. If you are gong to favour one turn above the other, favour the right-hand turn. If you get proficient in that you will automatically be proficient in the other.

Another important thing to remember is, never assume you have the sky to yourself. Before you make a turn, always look in the direction you are going to turn into to see that there are no other aircraft near. One is very much inclined to think that the sky is so large that the risk of collision is infinitesimal, but collisions do happen, and are very much worth guarding against.

Gliding turns are almost the same as level-flight turns, the only difference being in the position of the nose of the machine relative to the horizon. But because the stalling speed in a turn is higher than when a machine has no bank on, great care must be taken that you are gliding with ample speed. Better by far to have too much speed than too little. You know that when the engine is throttled back in a glide the elevator and rudder will not be so sensitive, so that greater movements will be required to get the desired result. This need not bother you. Just move the controls gently but firmly always, so far as to get the desired result. Before going into a gliding turn lower the nose slightly to get the little extra desired speed for a safe turn, then ease it up again when you have completed the turn. Always feel your ailerons by wagging gently from side to side in all these manœuvres so that you can be automatically sure that you are not dangerously near the stalling speed.

HINTS AND TIPS.

NEVER TURN TOO NEAR THE GROUND.

NEVER TURN TOO NEAR THE GROUND.

NEVER TURN TOO NEAR THE GROUND.

USUAL FAULTS IN TURNING.

You will find that it is not necessary to hold off bank in a gliding turn. Although the outer wing still obtains more lift owing to the greater speed, the inner wing is approaching the ground at a greater angle which counteracts the outer wing.

Failing to look round before turning.

Using too much rudder.

Holding off too much bank in turns with engine on.

Failure to keep nose of aircraft on horizon in turns with engine on.

Coming out of turns with insufficient bank or rudder.

Failure to come out straight and level.

CHAPTER SEVEN

TAKING OFF.

The purpose of taking off is to get into the air as quickly and as safely as possible. It is therefore necessary to take off **into** wind because the speed at which the aeroplane is airborne is dependent on air speed. Suppose, for example, the take-off speed (that is, the speed at which the aeroplane is airborne) is 45 m.p.h. and there is a 20 m.p.h. wind blowing. By taking off **into** wind the ground speed (that is, the speed of the aircraft relative to the ground) at the moment of take off, would be only 25 m.p.h., whereas by taking off **down wind** the ground speed would be at least 65 m.p.h. There are other reasons for taking off into wind which need not be explained here, but which relate to the question of safety.

If you are taking off from an aerodrome there will be indicators, such as a wind sock or a smoke trail, which will tell you the direction of the wind. If there is no such provision you must determine the direction of the wind before you get into the aeroplane. Having done this, taxi to that position on the aerodrome which will give you the longest run into wind. It is a very good rule always to take off into the maximum distance possible, clear ahead of you. For instance, do not start your take off from the middle of the aerodrome, although there may be plenty of room for you to get off. Go to the far boundary and use the whole of the aerodrome. By doing this you will have the maximum chance of making a successful forced landing in the event of sudden engine failure. If you use the whole aerodrome you will be twice as high above the far boundary than if you had used only half. Avoid taking off towards buildings or trees wherever possible, but you must take off dead into wind.

Having "taxied" to the correct position on the aerodrome, take a good look ahead to see that your plane is clear of other aircraft. Look behind to see that no aeroplane is coming in to land. If there is, wait for it to land before starting to take off. See that your machine is pointing directly into wind.

For taking off, the tail trimmer is put forward to a point about three-quarters along the quadrant. This assists in getting the tail up as you gather speed.

Now all is ready. Push your stick as far forward as it will go, taking care to keep it central. Open the throttle smoothly to its fullest extent and remember to keep your hand on the throttle the whole time. It is vitally necessary to ensure that during the run along the ground the aircraft keeps a dead straight course. You therefore pick out some object on the boundary that is straight ahead of you and keep it in view at least until the aeroplane is airborne. If there are clouds you may find it easier to choose some distant cloud; this is sometimes easier because you can see it without leaning your head outside the cockpit in order to look ahead. The main thing is to anticipate the nose turning to right or left, rather than wait until it has done so and then putting on a lot of rudder to correct it, which will probably mean starting a swing in the opposite direction. If this does occur close the throttle quickly, take the machine to the original starting point and try again.

Moving the stick forward enables the machine to get into flying position as soon as possible and staying there. The flying position is when the tail is in such a position that the machine will automatically become airborne when the necessary speed is reached.

Prior to taking off, the tail is close to the ground and the nose of the machine rises in front of you. As the aircraft gathers speed the tail is lifted off the ground and the nose gradually assumes the position you are accustomed to seeing it in during straight and level flying. At this point you ease the stick gently back so as to keep the aircraft level. You will find as the speed increases that you will have to continue bringing back the stick so as to keep the aircraft level until flying speed is reached, then the aircraft is airborne and you find the stick in the central position you are by now so used to. You are in the air, and realise this by the complete cessation of the bumping of the machine over the ground and the noise of the wheels trundling over the aerodrome. This is often described as one of the most pleasant sensations connected with flying.

After the aircraft has left the ground, keep it flying level a few feet above the ground so that it gains plenty of speed before you start to climb. For your training machine this will be about 60 m.p.h.

When you are climbing off the aerodrome continue to keep the machine flying straight. You must not think of trying to turn until you are at least 600 feet high.

If the engine should fail soon after taking off, the golden rule is to put the stick well forward and drop the nose, so as to maintain flying speed and GLIDE straight on. Do not succumb to the temptation of turning back into the aerodrome. The machine will be almost sure to stall. You may turn slightly to avoid obstructions but you must try and land into wind as far as possible. Do not turn sufficiently to be across wind.

USUAL FAULTS.

Failing to steer a straight course.

Allowing tail to become too high before easing stick back. This results, at the least, in running the propellor into the ground and may easily cause the aeroplane to turn over on to its back.

Pulling the stick back too soon and before the aeroplane is in flying position, resulting in a take off very near to stalling point and the machine not as completely under your control as it should be.

Commencing to climb before making certain that the aeroplane is flying straight and level under proper control and has reached a speed of at least 60 m.p.h.

HINTS AND TIPS.

Be sure to keep the point on the boundary or cloud always in your sight.

Should the tail have risen too high do not over-correct. This would start you climbing steeply, possibly before you have sufficient speed, and could result in a stall too near the ground to recover.

If any of the faults have developed before you are in the air, throttle back immediately, still keeping a straight course. When you have come to rest look to see that your path is clear, then go back to your starting point and try again.

CHAPTER EIGHT

APPROACHES AND LANDINGS.

We are now climbing steadily, continuing to do so until arriving at a height of 600 feet. Having reached this height the aim is to position yourself on the side of the aerodrome opposite to that from which the wind is blowing, so that you can make a landing on the aerodrome, into wind.

All nations throughout the world have decreed that you must fly this circuit using only left-hand turns, unless otherwise instructed. So imagine you are going to fly an oblong course round the aerodrome after you have completed your climb. The first side of the oblong being across wind, the second side down wind, the third side across wind, and the fourth side being the final glide into wind on to the

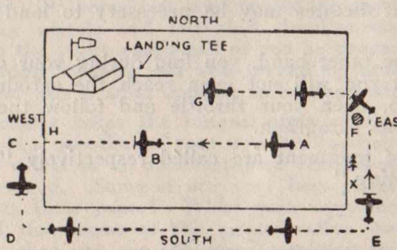


Diagram 12.—Across Wind.

The wind, as you will observe from the wind sock and the Landing Tee, is blowing from the West. Having taxied to A we follow the line in the direction of arrow, for take off. There is a gate at H you use for guide in keeping a straight course. At B the machine is airborne; climbs onwards to C, left-hand turn, and we are across wind, so be careful not to get blown too far to the West; along to D and another left-hand turn. Now we are going down wind and attain highest speed of the circuilt in relation to the ground. Turn again left hand at E and once again we are cross wind. At X there is a pine tree; we are at 600 feet and close the throttle. Putting the nose down we glide steadily at 60 m.p.h. (A.S.I.). Now we use rudder to keep on a straight course and at F we observe a small pond. We note the indicator says 300 feet. We make the last turn and glide again, into wind now, to our final touch down at G.

aerodrome. During this circuit the port wing tip of the aeroplane should appear to be running approximately along the boundary of the aerodrome. This will prevent you wandering too far away. Having reached the down-wind side, you turn across wind and after making this turn (the third turn), carefully survey the aerodrome in relation to your position. The next two or three movements are governed entirely by your own judgment, but on subsequent attempts over the same circuit, you can be assisted by carefully fixing in your mind the various landmarks in relation to your own position and height.

You have made your third turn and you are still at 600 feet. Now close your throttle and glide. At the point of closing your throttle pick out some object immediately below you on the ground and glance at your altimeter.

Glide across wind to a height of approximately 300 feet and then again glance at your altimeter and note some object on the ground, immediately turn into wind by means of a gliding turn and glide straight ahead. If your judgment has been good you will very soon realise that a landing on the aerodrome is posssible.

If you think that you will not be able to touch down or land close to the aerodrome boundary nearest to you, open your throttle, climb up again to 600 feet and do the circuit again, this time making such variations in the points at which you do your third and fourth turns as your judgment dictates may be necessary to land on the desired spot.

Suppose, on the other hand, you find during your glide after your fourth turn, that you will not even reach the aerodrome boundary, in this case also, open your throttle and follow the procedure set out in the previous paragraph.

These errors of judgment are called respectively "over-shooting" and "under-shooting."

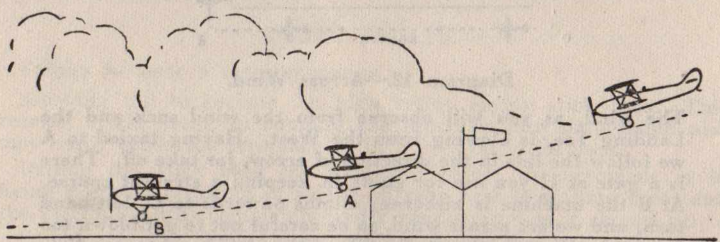


Diagram 13.—Landing: The Two Checks.

Here is the commencement of an actual landing. The machine is seen gliding in on the right-hand side, from the wind sock observe head into wind. You have ascertained that the height of the ridge of the hangars (A) is 20 feet. Make the slight decrease in gliding angle at that point. You hold the new angle until point B is reached one to three feet above the ground. Here you again perceptibly decrease the angle.

Now for the landing itself. At a height of 20 feet check your glide by easing the stick very slightly back. This check is not to bring the aeroplane to straight and level position but to reduce the angle of glide to a few degrees. Right up to this point your gliding speed has been at a steady 60 m.p.h. A final glance at the Indicator should never be made under 100 feet. Below that height your distance from the ground should be gauged entirely by your own judgment.

Just before you do your check at 20 feet, commence to look about 50 yards ahead of the aeroplane at an angle of 45 degrees, looking in this direction until the machine is safely on the ground. Continue to glide after this check until the wheels of the aeroplane are about one to three feet off the ground. The object now is to hold the aeroplane at this height until it finally stalls and drops on to the ground. To do

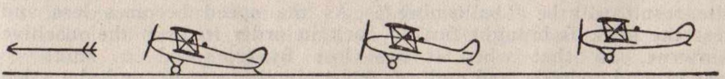


Diagram 14.—Landing: Last Stage.

As the speed drops you gradually bring the stick back. The nose slowly comes up and the tail down. This results in all flying speed (lift) being lost, and finally the ground is touched with landing wheels and tail skid simultaneously. As you look out, to the right and ahead of you be prepared to see the ground coming towards you and travelling underneath you; for this is what appears to be happening.

Landing usually takes the longest time of all sequences to master. It is a question of your eyes acclimatising themselves to accurate vision in an unaccustomed vertical plane. Do not get disheartened. Some of our very best pilots to-day made worse efforts than yours! When your eyes have become so accustomed then some of the concentration on this part is relieved, so that you can pay more attention to co-ordinating your stick movements to what your eyes see and so you acquire the knack of landing.

this the stick must be eased gently back until it has reached the limit of its travel. If you do this smoothly and correctly it will bring the tail down and by doing so bring the machine to the attitude in which you see it at rest on the ground, but a foot above the ground. As it has stalled in this position it will drop gently on to the aerodrome. Now keep the machine straight on the ground by means of the rudder until it has come to rest. Have a good look round before attempting to turn or taxi.

HINTS AND TIPS.

Try and gauge your height for the first check from some object on the ground of which you know the approximate height (a tree, fence, the hangars or the clubhouse). Practice will make this automatic.

For the second check you must accustom your eyes to the appearance of grass at a height of from one foot to three feet at a speed of 50 m.p.h. Both first and second checks are definite movements of the stick. The first check is a question of bringing the stick back and keeping it in this new position, resulting in a flatter gliding angle.

The second check is a continuous one, starting very gently and continuing to bring back the stick until the machine has arrived in the position in which it normally sits on the ground, nose up, tail down. To commence with, a slight backward movement of the stick is required. At this point the machine is flying straight and level at one to three feet over the aerodrome. As the speed of the machine becomes slower the stick is brought further back, so that the nose rises slightly. If the stick is brought back too soon, that is, before the machine has lost sufficient speed, or if brought back too much, the result will be "ballooning." As the speed becomes less and less the stick is brought further back in order to keep the machine airborne, so that when it has lost flying speed it sinks to the ground, wheels and tail touching simultaneously, and the stick should then have been brought as far back as it can go. As soon as the machine has touched the ground, glance straight ahead, sighting the nose of the machine on to some object on the distant boundary.

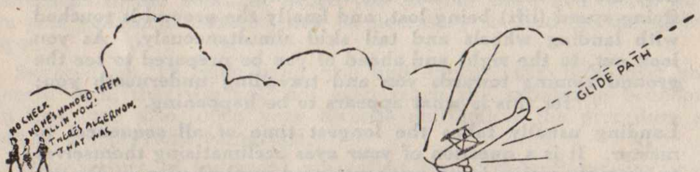


Diagram 15.—How Not to Land.

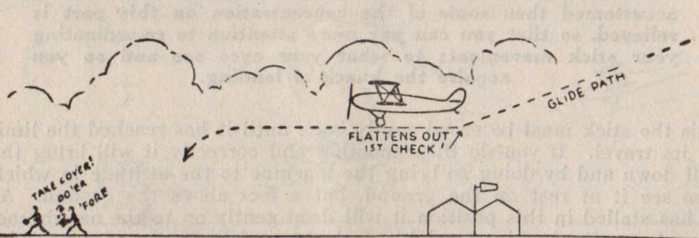


Diagram 16.—How Not to Land.

If you continue to do this until you have come to rest, you will have no difficulty in keeping a straight course by means of your rudder. Many machines have a tendency to pull one way when running along the ground at speed; be ready to counteract this at once.

Do not try to go through the sequences of landing unless you have got the approach right. You cannot make a good landing, which needs concentration, if you are worrying whether you will get into the aerodrome or not.

If the wind is at all strong then, when travelling across wind, it will be found necessary to turn the aeroplane sightly to the left (which means the nose of the machine will be pointing slightly into wind) to overcome the drift which would blow you too far from the aerodrome, causing you to undershoot.

USUAL FAULTS.

" Under-shooting " and " over-shooting."

Gliding too quickly.

Forgetting to make the first check and to gauge its height by checking up with the height of a known object on the ground, such as the hangars, etc. Generally speaking, there is very little tendency to not make the second check, for this would entail flying straight into the ground—probably on account of the fear of the result of such a proceeding; a most usual fault is to make this check, instead of one to three feet from the ground, at any height up to 10 feet, with, as a result, at least a damaged undercarriage.

CHAPTER NINE

TAXI-ING.

Any movement of the machine on the ground by means of its own power, that is, with the engine and propeller turning round, is known as taxi-ing.

You never taxi with the stick in any other position than right back.

You never taxi without first of all looking up to see you are not going to get in the way of, or cut across, any other machine that may be coming into land or just about to take off.

You never taxi until, in addition to making sure of this, you look to the right and to the left and forward on both sides of you to see that you are not going to taxi into any other machine or any obstruction on the aerodrome.

Never, under any circumstances, do you taxi in a hurry.

The throttle is opened only sufficient to allow the machine to move at a speed of 7 to 8 m.p.h. If it occurs that you have taxied to about the spot you wish to be in for, say, commencing to take off, and you have moved your rudder bar in the direction you wish to turn but there is little or no response, then it is permissible to open your throttle until the slip stream has increased to an extent that will allow the machine to answer to the control. This is in all circumstances merely a momentary opening—shutting immediately you have turned round. As you taxi, continually look out first right and then left as well as above, to still make sure that nothing has come in your way since you commenced to move.

When taxi-ing, the machine will not be so responsive to the rudder as when flying, and therefore you will have to make the maximum possible movement on the rudder bar when you wish to turn. As we are not dealing with advanced flying, and you are unlikely to be allowed to fly in a strong wind or in gusty weather, to avoid confusion no mention is being made here of any variation or addition necessary for the control of the machine in such weather.

GLOSSARY OF TERMS AND AIRCRAFT COMPONENTS.

Across Wind.—In the chapter on Landings reference has been made, in describing flying a circuit round the aerodrome, to the fact that after the first turn and after the third turn the machine is flying across wind. It means that the wind is trying to blow the machine sideways. In the lesson on Landings and Taking Off it has been shown that the importance of seeing that the machine is in both cases dead into wind is vital. When a machine is across wind it is naturally being blown out of or off the path that you wish to follow. When this occurs during a take off or landing it follows that there is a very severe strain placed on the machine in a sideways direction. If the strain becomes so high, through being very much out of your true dead into wind path, or if the wind is high, there is a great possibility of the undercarriage collapsing.

In order to keep on a straight line when flying across wind, the imaginary line drawn through the centre of the fuselage will not coincide with the line along the path that you are travelling. The nose of the machine will be on one side of it and the tail on the other. The amount of this angle across the line of flight will, of course, depend on the strength of the wind.

Read again, so that it impresses itself on your memory: "Never try to take off or land across wind." (See diagram 12, page 29.)

Aerobatics.—We can the better understand this term by the word formerly used for such evolutions. This was "acrobatics." In just the same way as people normally walk, run, sit and carry on the natural movements in daily life, we refer to a person who on the musical hall or circus carries out some movement removed from the normal ones as an "acrobat." It may be that he turns head over heels in the air. When an aeroplane does this it is called looping the loop.

If we are looking at the front of a machine and it rolls over sideways until the passengers are upside down, the aircraft has described a Half Roll. If the movement is continued until the passengers are once again flying along in normal level flight, a complete Roll has been executed.

If we imagine a machine at a height of several thousand feet diverting from its normal path of flight, so that its nose points towards the earth, whilst at the same time the machine revolves around an imaginary axis from the earth through the fuselage, then this evolution is known as a Spin.

Ailerons.—Ailerons are situated at the rear of the mainplanes and at the outer extremities of the latter in a position which, at a casual glance in their normal flying position, makes them appear to be just a part of the plane or wing. A closer examination will reveal that this part is hinged so that it can move upwards or downwards relative to the mainplane itself. They are controlled by the stick when it is moved from side to side across the cockpit. Their purpose is to raise one wing above the other, a movement necessary when turning. Their controls are inter-connected, so that as one goes down the other side goes up. (See diagram 7, page 15.)

Airborne.—This term is used to denote the transition when taking off, from a machine running along the ground on its wheels to that when it is actually taken off the ground and is supporting its own weight in the air. In a bad take off a pupil learning to fly might move the stick backwards too soon. The machine will then sometimes actually rise a foot or two in the air, and then drop to the ground. In these circumstances the pupil will have tried to get the machine off the ground before it was ready to be airborne, in other words, before it had sufficient speed to lift itself.

Sometimes when taking off from a bumpy aerodrome, or in very treacherous conditions, the wheels may strike a deflection on the ground that will momentarily jolt it into the air. This does not mean it is airborne and it will fall back on to the ground just the same as when attempting to " pull it off " too quickly.

Aligning the Wings.—In learning to fly we try to keep the machine flying with the wings parellel to the earth. In order to do so we sight them along the horizon. When we fail to do so the machine is flying one wing low, i.e., one wing lower than the other.

(See diagram 10, page 17.)

Altimeter.—This is an instrument which records the height of the machine above sea level. It will be appreciated that there are aerodromes at sea level and many more at varying heights above and below sea level. It is necessary therefore to have one common basis on which to determine how high above that basis an aircraft may be. If we look at a map giving the physical features of the earth we find the hills and mountains marked " so many feet," which, of course, is the height they are above sea level. Therefore, when an aerodrome is constructed, its height above sea level is determined. All altimeters are provided with an adjustment so that the needle may be set at sea level, or whatever the height of the aerodrome.

This adjustment is also necessary because the altimeter is operated by the same kind of mechanism as a barometer and is therefore subject to movement dependent upon weather conditions, irrespective of its altitude above the earth. These, however, for practical purposes may be ignored once the instrument is set for the flight.

When learning to fly we are not proposing to leave the precincts of the aerodrome, so then it is normal practice to set the altimeter to zero, because we are not going to traverse across mountain ranges that necessitate increasing our height to cross them, and it relieves the pupil of the mental calculations necessary to substract the height of the aerodrome above sea level from the basic zero to which the altimeter is set.

Angle of Glide.—This is the path followed by a machine when gliding to earth. It is then referred to as the angle of glide because if an imaginary line is drawn through the centre of the fuselage and continued to the point where it would strike the earth an angle is formed. Throughout his lessons the pupil will have been impressed with the necessity for ensuring that this angle is neither too steep nor too flat. It is determined by the necessity for keeping the speed of the machine when gliding at a sufficiently high margin above the stalling speed.

A.S.I.—This is short for Air Speed Indicator. At first thought, especially to people used to dealing with speeds on terra firma, this instrument is often regarded as a speedometer. This is entirely wrong as the A.S.I. does not record the speed of the machine relative to the earth. If a condition of dead calm ever prevailed and the density of the air always remained the same, it would be correct to regard the A.S.I. as a speedometer, but in point of fact these two conditions are never fulfilled. Therefore we must take time and be careful over what our A.S.I. is really telling us. Now we are flying along a straight and level path against a head wind of 20 m.p.h. We glance at the A.S.I. and we see it is recording 80 m.p.h. That is to say, the machine is doing 80 m.p.h. but is being blown backwards by the 20 m.p.h. wind at the rate of 20 m.p.h. Its relative speed to the earth therefore is only 60 m.p.h.

Now if we imagine that a 20 m.p.h. wind is coming across the machine, diagonally to the path we are following, then the wind will not blow us back at 20 m.p.h. but somewhere between 12 and 15, so that we may be doing relatively to the earth 65 to 68 m.p.h.

It is, of course, possible when in the air to compute precisely the actual forward speed of the machine relative to the ground under all and every condition. To do so, however, it is necessary to have instruments and to be able to make complicated calculations that are the function of a navigator and outside the scope of this book.

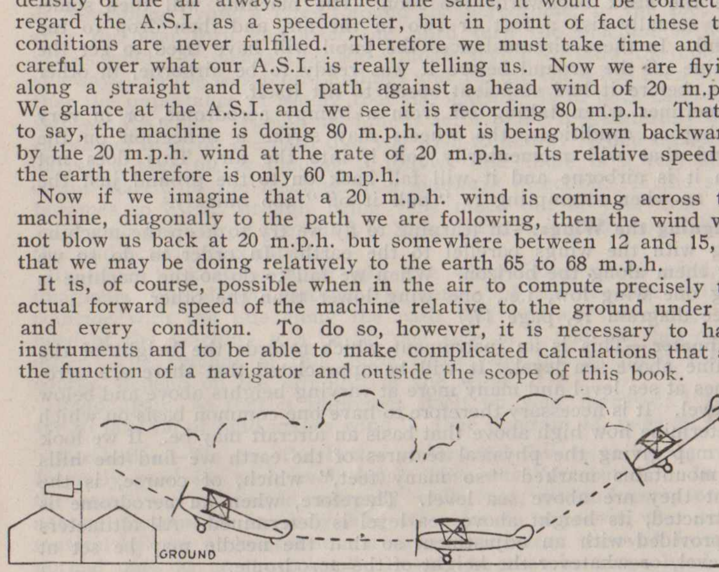


Diagram 17.—" Ballooning."

The result of pulling the stick back too far or too fast when landing, before the machine has lost flying speed. The final glide preparatory to landing was also too fast.

Ballooning.—When a machine is about to land you have been told to make a first and then second check. If you overdo either then the machine, instead of commencing a flatter angle of glide will assume an attitude of climbing. This is a highly dangerous procedure and must be checked immediately by pushing the stick forward, at the same time making quite certain that the operation is not overdone in the opposite direction and you fly into the ground. When the " checking " is overdone on the second check, then you balloon. (See diagram 17, page 36.)

Bank.—To bank a machine is to place it, by moving the stick either to one side or the other, into a position where the wings are no longer parallel with the ground but at an angle to it. " Bank " is a noun when used in the phrase "Now put on bank," which is one that your instructor in the early stages of learning to fly will frequently use, or he may say "More bank" or "Less bank." If, however, he should say "You are banking too much" it is in that case being used as a verb.

You have been taught in the chapter on Turning how, once you have obtained the correct degree of bank for the acuteness of the turn, you must then take steps to "hold it off." In other words, if you move your stick to the right, for a right-hand bank, say 2-in., a certain degree of bank will have been obtained. If you keep the stick in this position while it is turning, the bank will automatically become steeper. Therefore, as 2-in. gave you the correct amount of bank, it will be necessary to bring the stick back to normal flying position 2-in. or thereabouts to keep that particular steepness of bank. Of course, when you wish to come out of the turn, that is, when you have completed it, you then have to bring the stick over to the other side of the cockpit slightly. When the wings have once again resumed a line parallel to the ground, you bring the stick gently but firmly back to its central position. (See diagram 7, Ailerons, page 15.)

Centre of Gravity.—This is a point about which, if a machine were suspended on a cord to, for instance, the ceiling of a large building, it would automatically balance itself. First of all, imagine the machine resting on the ground on its wheels. If we attach a string on the centre line of the machine drawn from nose to tail, we will find that longitudinally the position where the machine would balance would be in the front cockpit. If we turn the machine over on its side we would again find that the string would have to be longitudinally at the same point. This is because all training machines are designed to have their centre of gravity in the front cockpit. This is so as it is the cockpit always used by the Instructor.

When you come to make your first solo flight this will result in the machine not "feeling" either nose heavy or tail heavy through his weight no longer being there, and removes one care from the first soloist's mind. Perhaps it can be appreciated better if we consider a training machine where the Instructor sat on the tail, then the machine would be "rigged" so that with the stick in its normal position the machine would fly a level path. If we were suddenly to take the Instructor away the machine would be wanting to fly tail high and the pupil would be put to the trouble of counteracting this by keeping the stick, not in the position he has grown to accept as normal, but much farther back.

Centre Section Struts.—The normal standard biplane trainer has wings or planes that will fold backwards so as to conserve storage space in the hangars. When they are folded back there remains in the centre of the machine, but above the fuselage, a fixed central portion. Although this is part of the wing area it is also the petrol tank and it is supported by four upright struts which are known as centre section struts.

If you are learning to fly on a monoplane which is not a standard trainer of the British Empire, then, of course, you will have no centre section struts to guide you in keeping the machine level in the rolling plane. You will therefore "sight" the side of the front engine cowl or perhaps a vertical support of the windscreen.

Centralise.—This phrase is used in connection with the centralising of your controls, after a turn. See " Bank."

Check.—In the lesson on Landings two checks are referred to. Dealing with the first one, which you must carry out at a height of approximately 20 feet, by bringing the stick slightly back, the effect of this is to lessen the acuteness of the gliding angle and to reduce the speed of the machine as you come nearer to the ground.

The second check you must execute at a height of one to three feet from the ground, again by moving the stick farther back still, being careful not to cause ballooning. This check is really the first portion of the slow steady bringing back of the stick until the machine has actually made contact with the ground. After the initial portion of the second check, causing the machine to fly parallel with the ground, the continued bringing back of the stick as the machine loses speed, brings up slowly the nose and down slowly the tail, so that when you actually " touch down " you do so simultaneously with the landing wheels and the tail skid. It will be apparent that from your seat you will now see that the nose of the machine in relation to yourself and the horizon is exactly that in which you have become accustomed to seeing it at all times when the machine is on the ground.

(See diagrams 13, 14, 15 and 16, pages 30, 31 and 32.)

Climbing Speed.—The best climbing speed is that at which the greatest height is gained in a minimum of time. You will on your Trainer probably be told that this is 65 or 70 m.p.h. There is another way in which the climbing capacity of an aeroplane is often referred to and that is the " rate of climb." As a matter of interest your Trainer should climb 5,000 feet in 9 minutes. In comparison, modern fighters approach 5,000 feet in a minute. (In 1917 the machine flown by the author over the lines in France, loaded with only 2 cwt. of bombs, took 45 minutes to climb 5,000 feet!)

The density of the air has a good deal to do with the number of feet climbed per minute. For every foot above sea level the density bcomes less. This has a two-fold drawback. In the first place, unless the engine is highly supercharged, which, of course, absorbs power, the current of air going into the engine becomes less and less, and therefore, whether supercharged or not, the power that is available to propel the machine becomes less, although there is an advantage when we do supercharge as against when we do not.

The second drawback is that because the air becomes thinner, which is the same thing as less dense, the lift of the aeroplane also becomes less, so that it is wanting to fall back instead of supporting itself. On the other hand, if we knew how to take full advantage of it, the lessened density of the air causing less drag on the surfaces of the machine, would more than counteract both.

Cockpit.—This is the space allotted for Pilot and passenger to sit in. It might be thought of as a compartment. In our standard training machines there are two cockpits, referred to as front cockpit and rear or back cockpit. When the pupil is under instruction the front cockpit is occupied by the Instructor, but if the machine is being used for a passenger flight it is occupied by the passenger. The Pilot sits in the rear.

Controls.—The controls are all the mechanism by which the necessary evolutions in the air are brought about, and although from a Pilot's point of view they are confined, when he speaks of them, to the stick and the rudder bar, the engineers and mechanics visualise all the apparatus going from these to the actual control surfaces.

Control Surfaces.—These control surfaces of an aircraft are those parts, such as the aileron, elevator and rudder surfaces, which can move independently of the component to which they are attached. We have seen how the ailerons move independently of the wings or mainplanes. The rudder lies behind the fin post. Whereas the fin is fixed the rudder may be moved a certain number of degrees to either side of the fin. The elevator is the other main control surface and this is attached to the tail plane, but whereas we can regard the tailplane for all practical purposes as fixed, the elevator is hinged, so that it may move a number of degrees up and down relative to the tailplane.

You will recall that a careful Pilot, before the engine has been started up, and as soon as he is seated comfortably, moves all his controls, watching the respective control surfaces while he does so to see that they are working. The first forerunner of the Flying Fortress was wrecked and all crew lost because the Pilot neglected to do this. The controls were locked.

Cruising Speed.—That is the speed attained by an aircraft as indicated by the A.S.I. when the engine is turning over at its normal revolutions per minute. It is the speed at which one generally flies, because to fly all the time at maximum speed not only puts the greatest load and consequently wear and tear on the engine, but uses up the greatest amount of petrol and oil in the shortest possible time.

(See also A.S.I. and Speed.)

Down Wind.—You are flying down wind when the wind is immediately behind you. You will remember that you must never try to take off or to land down wind.

It is as well to bear in mind that when you are flying down wind at, say, a cruising speed shown on the A.S.I. of 80 m.p.h., you are travelling at a greater speed than this relative to the earth. If your A.S.I. is registering 80 m.p.h. and you have a 40 m.p.h. wind behind you, for all practical purposes you are doing 120 miles per hour over the ground.

Drift.—Drift is said to occur when a machine is drifting, and this takes place when you are flying across a wind and you do not take the necessary measures to ensure that the machine is held on that path that you wish it to travel upon.

(See also Across Wind.)

Engine Off.—This is a phrase which, strictly speaking, does not mean what it would appear to. When you are gliding you do so with "engine off." In fact, your engine is still going round, but you have moved your throttle lever back and so you are not relying on engine power to support you in the air.

Engine On.—When you open up your throttle it is sometimes referred to as putting "engine on."

Elevator.—This is a control surface and its function is to control the machine in ascending or descending, otherwise known as the "pitching plane." Technically, an elevator, as also other control surfaces, is sometimes referred to as aerofoil. (See diagram 1, page 4.)

Flaps.—Flaps are fitted to some monoplane trainers; all commercial and war planes have them. Like the ailerons they are hinged surfaces in their simplest forms. Because this type is hinged to the rear edge of the wings, up to the ailerons, they are called "split trailing edge flaps." They are hinged on the underside of the wings and are 12 in. to 18 in. deep. When brought into operation they come down at an angle to the wing and act as an air brake used for landing. They reduce the speed and increase the angle of glide so that machines fitted with them can land in a smaller area.

Some flaps, such as the German Junkers and American Fowler and Marendaz are of use for taking off as well as landing as they increase the effective wing area. The Marendaz is the only flap that can be used for the full span of the wings (so giving greatest possible increase of area). They do not shroud the aileron but, by forming a gap between themselves and the mainplanes, increase the velocity of air in the vicinity of the ailerons, thereby increasing their effectiveness at low flying speeds—a very desirable feature.

Forced Landing.—A forced landing is one which is involuntary as far as the Pilot is concerned. It may be that the engine has failed. It is therefore imperative to make a landing. If weather conditions whilst in the air have become such, either through wind or snow, or perhaps a thunderstorm, as well as visibility being so bad that it is expedient to land, without waiting to arrive at an aerodrome or at your destination, you will be making what is known as a forced landing. More often than not this will be on land that has not been prepared as an aerodrome.

So soon as you are able to become a little less preoccupied with the actual controlling of the machine, before you go solo, it is a good plan to consider from time to time when in the air, what spot you would choose to make a forced landing on if your engine should happen to fail at any particular moment.

Fuselage.—This is the body or backbone or hull of an aircraft. On either side and towards the front are fixed the wings or planes. In the forward position of the nose some designs have the engine. In other types the Pilots sit in the nose and the engines are situated in the wings. In the fuselage are the cockpits for pilot and passengers. To the rear end of the fuselage is attached the tail plane consisting of fin, rudder, the tailplane itself and the elevator.

Horizon.—In learning to fly the horizon is of great importance because in good flying weather it is easily seen and an immovable object, relative to which you can gauge the attitude of the aircraft and its line of flight.

Not only is it immovable and readily seen but, no matter what point of the compass you may be travelling towards, there is always in front of you the horizon.

It is, relatively to the short distances that we travel on earth, always to all intents and purposes in the same position with regard to your machine. You will undoubtedly at some time have climbed a high hill or a mountain. The extreme limit of your view is the horizon. Whether you look to the front, the side or the rear, there is always the horizon.

Horizontal Axis.—The horizontal axis of the machine is a line drawn horizontally through the centre of the fuselage lengthwise.

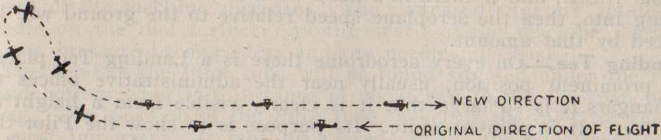


Diagram 18.—An " Immelmann " Turn.

Immelmann Turn.—This is an evolution so named through it first being performed by a German pilot of that name in the World War 1914-1918. If we consider that we have carried out a Zoom but, instead of at the top of the climb, straightening out and flying straight on, we turn suddenly either right or left and in doing so lose the same amount of height as we did in executing the Zoom, then we have described an Immelmann turn. The speed of present day Fighters is so high that the relatively increased speed of such a turn would be too great for a pilot to execute without " blacking out," or becoming unconscious.

Into Wind.—This is the reverse of down wind. It is when you are flying directly into the direction from which the wind is coming; and it is the direction that you always take off into and land into. If you are flying into a wind of 40 m.p.h. and your A.S.I. is registering 80 m.p.h., your speed relative to the earth will only be 40 m.p.h.

Inverted Flight.—This is almost self explanatory and means that a machine is flying along on its back. If we do a half roll and then continue to fly in level flight, this particular aerobatic is being carried out.

Lag.—This is a technical term referring to the lapse of time in the correct registering by an instrument caused through, in the case of the A.S.I., the distance the air has to travel from the point of entry into the Pitot tube until it reaches the recording part of the mechanism.

In the case of the Altimeter, we have referred to its principle of operation being that of the barometer, and we know that, in order to make a barometer register the state of the weather at any particular time, we have to tap it. We cannot spend the time to tap an Altimeter and even if we could, as conditions change from one split second to another, it would not be much use. We therefore have to make allowances for the fact that, if we are gliding and our Altimeter shows 500 feet, we have probably descended at least another 100 feet which the instrument has not yet been able to adjust itself to, so it is registering 100 feet on the high side. One of the reasons why this is stressed is that you should learn to fly by touch, hearing and sight, and not instruments.

Landing Speed.—This is the slowest speed at which it is safe to glide an aeroplane without fear of stalling and with the Pilot retaining power over each and every control. The landing speed of your Trainer will be 55 to 60 m.p.h.

It will be apparent that there is a wide margin between the landing and the stalling speed. Variations in the note of the machine as it glides you will soon be able to detect.

Both landing and stalling speeds given above are those registered on your A.S.I., and if there is a head wind of 20 m.p.h. that you are landing into, then the aeroplane speed relative to the ground will be reduced by that amount.

Landing Tee.—On every aerodrome there is a Landing Tee placed in a prominent position, usually near the administrative offices or the hangars.It is so large that it is clearly visible from a height of 1,000 feet. It is painted white. Its purpose is to show the Pilot the direction in which he is to land. It is the duty of a responsible official to see, if it it not an automatic Tee, that it is always pointing into wind. Into wind means that the small bar which forms the top of the Tee is pointing towards the wind. The Pilot knows, therefore, that he is to land parallel with the long stroke of the Tee and into the short one.

On some days the wind is so calm that it is insufficient even to extend the wind sock. Other days it is so gusty and boisterous that the wind sock veers round continuously. It is on these occasions that the Pilot is guided in which direction he should land by the Landing Tee. (See diagram 12, Across Wind, page 29.)

Maximum Speeds.—This is determined when flying level at sea level. The design of the propellor has much to do with the characteristics of the machine, especially so when the blades are fixed as on your Trainer. For maximum speed, the coarser the pitch up to a point, the greater the speed, but a coarse pitch operates against a fast climbing speed. As a consequence, all machines with fixed props have one which is a compromise for general purpose use. The variable pitch propellor, standard on most military machines and passenger liners, to some extent overcomes this disadvantage. It would be entering too deeply into aircraft design to explain why it does not completely overcome this.

Monoplane.—A monoplane has two wings, one on each side of the fuselage. A Biplane has four wings, two on each side of the fuselage, situated one above the other.

A High Wing Monoplane has the wings attached to the top of the fuselage.

A Mid Wing Monoplane has the wings attached to the middle of the fuselage or thereabouts.

A Low Wing Monoplane has the wings attached to the bottom of the fuselage.

Pitching Plane.—The word "Plane" in this term does not refer to the wings nor to the machine itself. We know that, as distinct from earthbound locomotion, whether on land or sea, which can only move to the right or left and not up and down, the aeroplane can move in all directions when in the air. It is desirable, therefore, to define by some distinct term these movements. When an aeroplane rises and falls, movement is taking place in the pitching plane. (See also Rolling Plane and Yawing Plane.)

All movements that it is possible for an aeroplane to make fall either in the category of one of these three, or else in a combination of two or more. (See diagram 9, page 16.)

Pitot Tube.—This is the component through which air is allowed to pass down an open tube to the A.S.I. dial on the dash of the cockpit.

The air travels down with increasing velocity and pressure as the speed of the machine increases. The increased pressure rotates the needle on the dial farther. As the speed of the machine decreases so the pressure becomes less and the needle falls back.

The head of the Pitot tube will be found situated under the right-hand bottom wing at a distance of about two thirds the span of the wing. The position of the Pitot tube, which is the inlet for the air, is most important. It must be placed outside the slipstream of the propeller, otherwise the tremendous pressure of air thrown back by the propeller, would operate the A.S.I. and render it useless from a Pilot's point of view.

Port Wing.—When a Pilot is sitting in his cockpit, the port wing is the one on his left-hand side and the starboard is the wing on his right. This nomenclature, as distinct from right and left, is, like the propeller, borrowed from the sea.

Propeller.—This word is derived from the verb to propel. You will never hear the word "propeller" mentioned when you are learning to fly, nor in the hangars and workshops. It is always referred to as a Prop.

Its function is to draw the machine through the air and when it does so at a sufficiently great speed the air operating on the wings causes the machine to lift. An aeroplane propeller is akin to the propeller of a ship, with the exception that all aeroplanes to-day have the propeller in front and are therefore technically known as tractor propellers, whereas a ship's propeller is behind the mass of the boat and is not of the tractor or pulling type, but propels or pushes. Aeroplane and ship's propellers are sometimes referred to as " screws " and this is because they are so shaped that they screw themselves through the air or water.

In the early type machines it was just as common to have propellers behind the mainplanes as it is now to have them in front.

The constructional difficulties of placing them in this position in the next phase of aircraft construction rendered the placing of the propeller in front necessary, and there it has stayed ever since, largely on account of fashion.

Machines of the present day, muti-engined monoplanes which we are so familiar with, might conceivably be improved in performance by placing the propellor behind the wings.

It cannot be emphasised too greatly that the greatest possible care should be taken to ensure that you do not get too close to a propeller whilst it is rotating. If you are wearing a coat or a scarf, its action is to draw these garments towards itself with, of course, only fatal result. It is recommended that you never walk closer than ten yards from the front of a revolving propeller unless it is absolutely necessary.

If you are standing behind a machine that is about to be started up, do not be caught unawares but be prepared for the tremendous draught that might easily throw you backwards.

Quadrant.—On the side of the pupil's cockpit is a lever which works in a quadrant. The object of this lever is to alter the amount of lift that the aeroplane receives from its tail. By moving this forward before taking off it helps the machine to rise. Once you have attained the height desired, and to relieve the Pilot of the necessity of always keeping the stick forward during level flight (to prevent the machine from continuing to climb) the lever is brought backwards into the quadrant until the machine flies of its own accord, with your hands off the stick, in level flight.

The position that it is moved back to for level flight will depend on the speed you wish to fly at.

You will be told, and will soon become accustomed to, the proper position for taking off and the correct back position for normal cruising speed and landing.

Revs.—This is a short phrase used by flying personnel, meaning Revolutions per minute.

On starting an engine, after warming it up, the Pilot tests it and if it is giving the full numbers of revs. per minute—we are supposing it is 1,500—with the throttle fully opened, then the Pilot would say to the mechanic " Engine revs. are well up." If it only reaches 1,450 he would say " She is 50 revs. down."

Revving.—This is a verb meaning to keep up the revs. per minute by means of opening the throttle.

Rigging.—To give a precise definition of this word, as applied to aircraft, would necessitaete going into many technicalities. Perhaps some idea of its meaning may be obtained by imagining the machine to be at rest on the ground but with the tail on a trestle, so that the machine is standing in flying position. That is to say, the position it would be in when flying straight and level. We will now walk to the side of it, at some distance away. Close observation will allow us to see that the wing is so arranged in relation to its fixing to the fuselage that the leading edge is higher than the trailing edge.

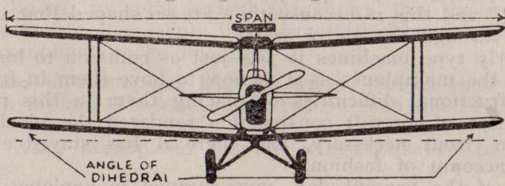


Diagram 19.—Rigging.

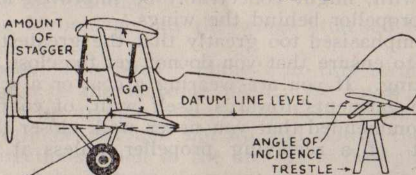


Diagram 20.—Rigging.

This is known as the angle of incidence. If the leading edge was arranged so as to be higher up the fuselage and the trailing edge farther down, then the rigging would be arranged so as to make the machine want to fly at cruising speed with its nose in the air. This is known as nose light.

If we reversed this process and pressed the leading edge down and the trailing edge up, then it would want to fly with its nose downwards. This sometimes occurs if the machine has not been rigged correctly and the test pilot will report it as being nose heavy.

Now we will remain on the side but move so that we are opposite the tail. Here we will have to look more closely and will probably find that the front of the tail, ignoring the elevator, is higher than the rear. The position of the front of the tail relative to the rear in relation to the fuselage, does exactly the same thing as we have seen occurs with the mainplanes; if the machine is not rigged correctly it will be reported as being tail light or tail heavy.

Now we will walk to the front of the machine, some 15 to 20 paces ahead of it, and observe that the wings do not lie in a flat plane. The wings rise upwards from the centre section. They do so at a precise angle pre-determined by the designer. This angle is known as the dihedral.

The engineers have to be careful that the correct amount of dihedral is given to each wing when they are rigging the machine. These and other similar matters constitute the rigging of an aircraft, which, if done properly, given a good aircraft, makes it comfortable to fly. You will soon observe little differences in the way two machines of the same type " handle." These differences will be due to the way they are rigged. (See diagrams 10 and 20, page 45.)

Rolling Plane (see Diagram 8 on page 16).—Imagine a machine suspended in the air mounted on a spindle that runs from the nose to the tail, then, if we press down the port wing, the starboard wing will rise. We are then making a movement in the rolling plane. If we continue pressing we will bring the machine so that it is in the attitude adopted for a vertical bank; that is to say, its wings are at right angles to the ground.

If we then continue to push the port wing until it has described a complete circle, the machine has in fact completed a roll. The only difference to an actual roll in the air has been the fact that as the machine was rotated about its horizontal axis it was not at the same time going forward, as, of course, it would be if it were flying.)

R.P.M.—This means Revolutions Per Minute. An engine gives out a certain power for a certain number of revolutions per minute. If your engine is, say, 110 h.p. it will develop the maximum horse power at a certain number of revs. per minute, say 1,500.

Rudder (see also Control Surfaces. See Diagram 1 on page 4).—The rudder is a movable surface at the extreme rear of the tail, and when in normal position for straight and level flying appears to be part of the fin.

It can move from side to side about a vertical axis. When you push the rudder bar with the right foot it brings the rudder around to the right; this action sends the machine to the right. Do not forget when turning in the air you must never move the rudder bar, either to right or left, without at the same time applying the appropriate amount of bank.

When the machine is being taxied on the ground the rudder functions in exactly the same way and a movement to the left will cause the machine to turn to the left.

Side-Slipping.—This evolution is carried out when a machine is gliding with engine off, but instead of the nose of the machine aligning itself upon a straight line between the pilot and a point on the ground immediately in front of him, if we are side-slipping to the right, the nose will be to the left of that line, and if we are side-slipping to the left, the nose will be to the right of the line.

Side-slipping causes the machine to lose considerably more height for the distance travelled relative to the earth than normal gliding does. It is often used therefore by experienced pilots when they may have to make a forced landing in a very small area. (See diagram 21.)

Side Slip.—See Chapter 6 (not aerobatics).

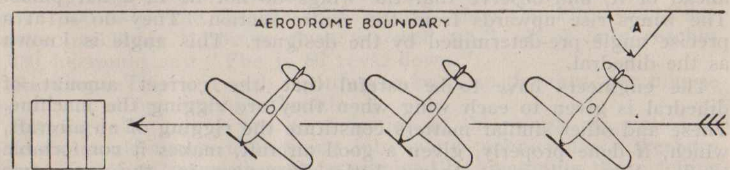


Diagram 21.—Side Slipping.

Once again you are up in your balloon at a height of say 2,000 feet. Below you you see a machine whose wings are at the angle A to the boundary of the aerodrome and yet the path followed by the machine is that of the arrow. The machine is side-slipping. In this evolution much height is lost for the distance glided over the ground. The side slip shown in the sketch necessitates the right wing (looking from the pilot's seat as always) being lower than the left—banking but not turning.

Slip Stream.—This is the current of air sent backwards by the propeller when it is rotating. (See also Propeller.)

Smoke Trail.—Many aerodromes, in addition to a wind sock and a Landing Tee, have a Smoke Trail. This consists of an artificial device giving off a continual smoke. If there is a wind it will, of course, take the smoke with it. A Smoke Trail is a very convenient and easily seen method for determining which way the wind may be blowing.

If you have to make a forced landing into a field there will, of course, be no wind sock and no landing tee. It is just as well therefore as you fly to observe such smoke as there may be from chimneys, or even the steam from a train, although the latter is not so good, so that should your engine fail you have not to wonder which way to turn to land into wind.

Speed.—So far as an aeroplane is concerned, this is a very different matter to that of a motor cycle or car or other locomotion on terra firma. An aeroplane has many speeds, the most important to those learning to fly being the stalling speed, the speed when it ceases to fly, and which in your Trainer will probably be about 45 m.p.h., when gliding. But this is not ground speed. This is the combined speed of the head wind, if any, and your speed in relation to the ground.

Stalled Attitude (see Diagram 11 on page 20).—This is the position a machine assumes in the air just prior to falling out of control and putting its nose down. You cannot fail to realise when the machine has arrived at the stalling attitude. The nose will be well above you and there will be an entire loss of response to any movement of the controls..

Some types of machines will maintain this stalled attitude almost indefinitely and this performance is called "hanging on your prop."

All this only refers to a machine flying with engine on at normal or maximum revs. If you are gliding it will most certainly stall long before the nose of the machine rises above you. How you avoid this has been dealt with in Chapter 5.

Starting An Engine.—What follows refers entirely to starting the engine of your Trainer as distinct from the various forms of starting utilised in larger engines fitted into commercial machines and warplanes.

You have already been warned as to the danger of getting into the proximity of a propellor when running. It is at least as dangerous for the uninitiated to attempt to start an engine without very thorough previous drill on a dead engine. A dead engine is one in which the actual ignition from the magneto to the plugs has been disconnected, such as taking the leads off the plugs.

So far as the Pilot is concerned we will imagine he is sitting in the cockpit. The throttle is on his left-hand side and is operated by that hand. Situated on the outside of the fuselage, forward of him, are two switches. By putting his right hand outside the cockpit and immediately forward, they come easily within reach. The mechanic goes to the front of the machine near to the propellor and calls out to the Pilot: "Switches off, throttle open, suck in." The Pilot switches off or puts his hand on them to see that they are off and then calls out to the mechanic: "Switches off, throttle open, suck in." The mechanic then proceeds to turn the propellor by hand for three or four turns, stops and then calls out: "Throttle closed, contact." The Pilot closes the throttle, switches on and calls back to the mechanic: "Throttle closed, contact." The mechanic then swings the propellor and the engine should start. If it does not, the performance is repeated until it does.

There must be no slackness on the part of the Pilot over the above procedure and there must be no question of him calling out that the switches are on if they are off, or vice versa.

Before attempting to start an engine, chocks are placed in front of the wheels so that the machine will not commence to run along the ground as soon as it starts up. The Pilot is responsible for seeing that the stick is held right back after the word "Contact" is called out, so that there will be no tendency for it to turn over on its back.

Stick (see Diagram 5, page 13).—This is the means by which, when it is moved fore and aft, longitudinally up and down the cockpit, the Pilot controls the elevators. It is so arranged, when moved from side to side laterally, that it also operates the ailerons.

The stick is also referred to as a joy stick. In larger machines it is sometimes operated by a wheel at the top of the stick or column and it is then called a control column. The functions are identical.

It is just as well to see that the stick is firmly secured, as in all Training machines they are made detachable. With normally thorough inspections it is hardly likely that a machine would be put on the serviceable list unless it were so, but in all matters concerned with flying the utmost care and attention to detail results in a long life free from accidents.

Switch Off.—See Starting of Engine.

Tail Trimmer.—The tail trimmer is on the left-hand side of the cockpit and consists of a lever that can be moved over a distance of some 12 in. to 14 in. fore and aft. The lever operates in a quadrant. (See also Quadrant.)

Throttle Back.—This is when the lever is moved right back and you will remember that you do this before you commence to glide.

Throttle Closed.—See Throttle Back.

Throttle Lever.—This is the lever on the left-hand side of the Pilot that controls the engine revs. above idling speed. All throttle levers are set so that they cannot be moved far enough back to stop the engine. This is very important as it is not a pleasant experience to have your engine stop in mid air. Moving the throttle forward away from you increases the speed; bringing it back decreases it.

Throttle Open.—This is moving the lever forward. Fully forward for taking off and the initial climb; three quarters forward for cruising.

Touch Down.—See Chec :.

Under Carriage.—This consists of the wheels, out-riggers and supports, shock absorbing devices and so on, upon which the aeroplane depends for support when on the ground. It is also referred to as landing wheels or wheels. The latter, in the singular, is sometimes applied when an indifferent landing is made and you touch down on the landing wheels alone, the tail and tail skid still being in the air. This is what is called a wheel landing.

The undercarriages of all machines other than Trainers are now arranged so that when the machine has left the ground the whole of the wheels and supports fold into the machine at the will of the Pilot. They are lowered again by the Pilot moving a lever when he wishes to land. This type of undercarriage is referred to as a retractable undercarriage.

Visibility.—To the average layman visibility in daytime, unless it is nil as during a thick fog, is of little concern. To the Pilot it is most important. Haze, low-flying clouds and such-like restrict visibility. For earthbound people, if they are able to see two miles ahead when standing on a small hill or a high promontory, this does not restrict their movements. For the Pilot, however, flying a machine with a very modest speed of, say, 120 m.p.h. it means that he is only able to see one minute's flying ahead of him, and unless he knows the ground well, or is an expert navigator, much difficulty ensues in finding his way.

Great danger also arises in the case of poor visibility should a forced landing become necessary. The importance of visbility is such that all weather reports include the extent of it. The terms used may vary from " Visibility nil " to " Visibility clear."

Wind Sock.—This is a circular bottomless shaped sack called a sock; the mouth is held open by a ring to which is attached a cord, in turn tied to the upper end of a long pole or mast. The length of the sack is three feet to four feet, and as the wind blows through, it extends. It is easily ascertained which way the wind is blowing, for it always enters at the large front end and leaves at the narrow end. It is usually yellow or white in colour and placed adjacent to the administrative or hangar buildings, but not in a position where it is shrouded from the wind.

Wing Area.—This is easily understood if we take all wings (two or four) and place them on the ground one by one. They will then be covering a certain area. If we measure, in feet, the length and breadth of one wing, and multiply them together, the answer will be the area in square feet of that wing. If we do likewise with the other three, assuming the machine is a biplane, and add the four totals together, the total wing area will be arrived at.

Wing Tip.—The wing tip is the extreme outer end of the wing, the very furthest point away from the cockpit.

Yawing Plane (see Diagram 6, page 14.)—Let us imagine we are at a height of 5,000 feet in a balloon and below us we see an aeroplane flying due north. As we watch, the machine turns to the east. It has made a movement in the yawing plane. Any change of course will be a movement in the yawing plane. For the purpose of this definition we have wrongly assumed that the machine has moved to the right or to the left, the east or the west, without banking. As, of course, the machine would have banked in order to change its course, then it would have made a movement in the yawing plane combined with a movement in the rolling plane.

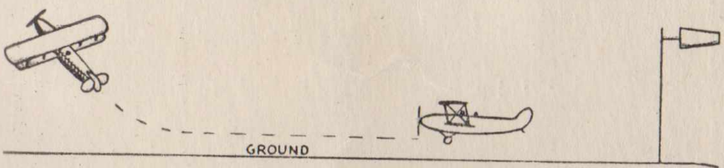


Diagram 22.—Zooming.

Zooming.—This is a term applied to flying parallel to the ground at a fast speed, and suddenly pulling the nose of the machine up so that it shoots up into the air at an angle very much steeper than a normal climb and at a much greater rate.

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