

fundamental maneuvers of flight



chapter 3

All flying technique is based upon one or more fundamental maneuvers of flight. In learning to fly, as in any learning process, you must master fundamentals before you can undertake the more advanced problems of flight. Your ability to master these fundamentals will greatly speed up your progress in mastering the more advanced maneuvers in the primary flying curriculum.

EFFECT AND USE OF CONTROLS

Each flight control has its effect on the attitude of the aircraft and controls the movement about one of its axes. You should learn these effects in order to control the aircraft and to obtain the desired responses. Your instructor will demonstrate the effects and use of the controls from straight and level flight at cruising speed. These same effects will apply, regardless of the attitude of the aircraft. You should think of yourself as the pivot point about which all changes of attitude or movement occur.

Axes of an Aircraft

There are three axes about which an aircraft will rotate and three flight controls which may be used to control the rotation. The axes are the lateral, vertical, and longitudinal axes; the flight controls are the elevators, rudders, and ailerons. They are defined as follows:

Lateral axis: An imaginary line which runs

from wing tip to wing tip through the center of gravity and is perpendicular to the longitudinal and vertical axes. Rotation about this axis (pitch attitude) is controlled by the *elevators*.

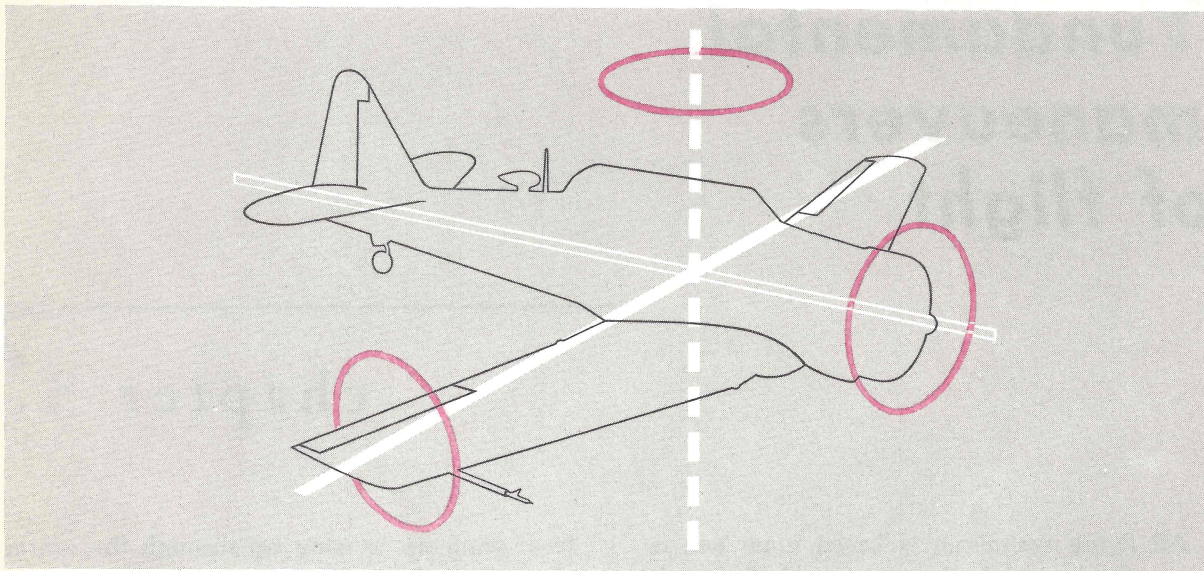
The elevators are the movable horizontal surfaces on the tail of the aircraft and are controlled by forward or backward pressure on the stick. When forward pressure is applied to the stick, the nose moves away from you. When back pressure is applied to the stick, the nose is brought toward you.

Vertical axis: An imaginary line which runs through the center of gravity and is perpendicular to the lateral and longitudinal axes. Rotation about this axis (yaw) is controlled by the *rudder*.

The rudder is the movable vertical surface on the tail of the aircraft and is controlled by pressure on the rudder pedals. When pressure is applied to the right rudder, the nose will move to the right. When pressure is applied to the left rudder, the nose will move to the left.

Longitudinal axis: An imaginary line which runs through the center of gravity from propeller to tail. It is perpendicular to the lateral and vertical axes. Rotation about this axis (roll) is controlled by the *ailerons*.

The ailerons are the movable panels in the outboard trailing edge of the wings and are



Axes of the Aircraft

controlled by side pressure on the stick. Pressure on the stick toward the right wing lowers that wing. Pressure on the stick toward the left wing lowers that wing.

Tips

Always remember that to get the desired results from the controls, you should think of using pressures and not actual movements.

The effect and use of the controls have been taken up individually, but you should realize that no one of these control movements constitutes a maneuver. In order to fly your aircraft efficiently, you must use the controls together. This is known as coordination of controls and is vital to smooth flying.

USING THE CONTROLS

Now that you know how the aircraft will react when the controls are used, you must learn how to use them properly. Rough and erratic usage of all or any one of the controls will cause the aircraft to react accordingly, so it is important that you be able to apply the pressures smoothly and evenly.

How to Use the Rudders

The position of the feet should be comfortable with all the weight on the heels; this allows a fine sensitivity of touch in the balls

of the feet. Let the heels of your feet rest comfortably on the catwalks located directly beneath the rudder pedals. Slide your heels along the catwalks until the balls of your feet, or your toes if you have short feet, rest comfortably on the rudder bars. Don't let your legs and feet become tense but keep relaxed just as you do when driving an automobile.

When you use the rudders, apply pressure smoothly and evenly by pressing with the ball of one foot just as if you were using the accelerator in an automobile. Of course, when one rudder is pushed forward, the other will come back an equal distance. Make large pressure changes by applying the pressure with the balls of your feet and let your heels slide along the catwalks. Remember, let the balls of your feet rest comfortably on the rudder bars so that you can feel the pressures.

Don't try to fly with your heels on the rudder bars as if you were steering a sled or scooter. If you do, your legs will become tired and tense and you will not be able to feel the rudder pressures properly.

How to Use the Stick

You should grasp the stick lightly with the fingers, not grab or squeeze it. Hold the stick

the same way you would hold the steering wheel of an automobile — relaxed and comfortable. It is important that your arm and hand be relaxed so that you may feel any pressure that may be exerted on the stick. Except in acrobatics or violent maneuvers, the pressures should be exerted with the fingers.

It is the pressure exerted on the stick and rudder pedals that causes the aircraft to move about its axes. When a control surface is moved out of its streamlined position, the air flowing past it will exert pressure against it and will try to return it to its streamlined position. It is this pressure that you will feel on the stick and rudders.

The amount of pressure that is exerted against a control is governed by the speed that the surface is traveling through the air and the degree that it is moved out of its streamlined position. Since the airspeed will not be the same in all maneuvers, the actual movement of a control surface is of little importance. It is, therefore, important that you be able to maneuver the aircraft by applying pressure to the controls to obtain a desired result, regardless of how far they are actually moved.

This may be better understood if you think of the technique used in driving an automobile. When steering a car around a curve you don't turn the steering wheel any certain distance; instead, you hold whatever pressure is

necessary to keep the car in your lane. The sharpness of the turn and the speed of the car govern how much pressure must be used. For instance, at high speeds you would use more pressure than you would at low speeds.

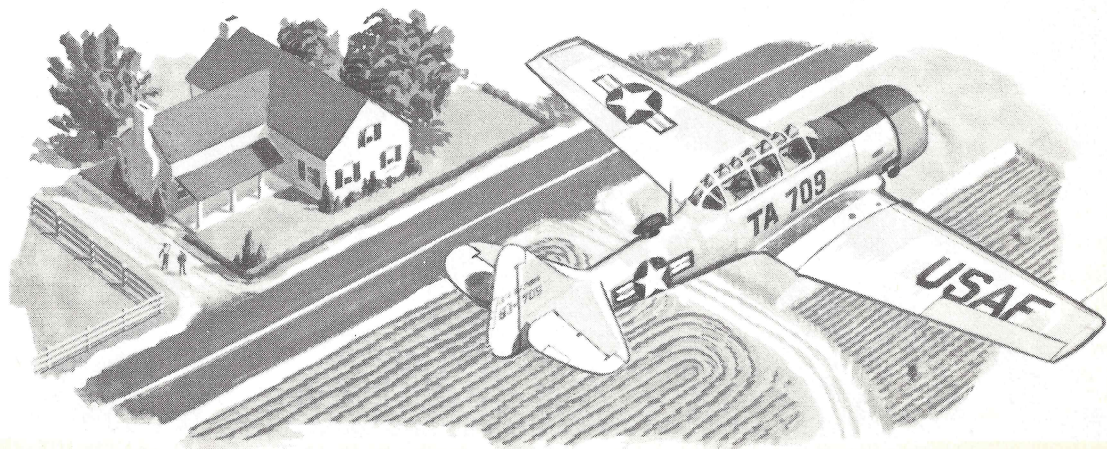
STRAIGHT AND LEVEL FLIGHT

Straight and level flight is just what the name implies — flight through the air in which constant altitude and direction are maintained. In the pre-solo phase of training, it demonstrates one of the basic fundamentals of flying. You will learn the use of the controls; the use of visual references to help you determine aircraft attitude, that is, noticing the position of the nose and wing tips of the aircraft with reference to the horizon; and the importance of dividing your attention, that is, constantly checking all reference points and not concentrating on any one point. Your primary training objective in this maneuver is to attain proficiency in these three things.

Before practicing straight and level flight, you must understand thoroughly the effect and use of the controls; be properly and comfortably seated in the aircraft; and be completely relaxed and at ease.

It is important that you understand the effect and use of the controls so that when attitude corrections are necessary, you will know what pressures to apply to which controls.

Your perspective of the visual references on



the aircraft, in relation to the horizon and ground, change as your eye level changes; consequently, different seating arrangements will result in different perspectives, although one flight attitude is being held constant.

Being relaxed and at ease in the aircraft means that your body is free of muscular tension. When your body is free of tension, it can more readily feel any pressure that may be exerted on it by centrifugal force or gravity; also, it can better gauge the amount of pressure that you are applying to a control. It is imperative that you maintain a good posture while seated in the aircraft so that your body will remain relaxed and your visual references will always appear the same. Looking around and maintaining a constant flight attitude are very important in this and all other maneuvers.

Straight and level flight is accomplished with the following conditions of flight.

Throttle at 25" Hg

Propeller at 1850 RPM

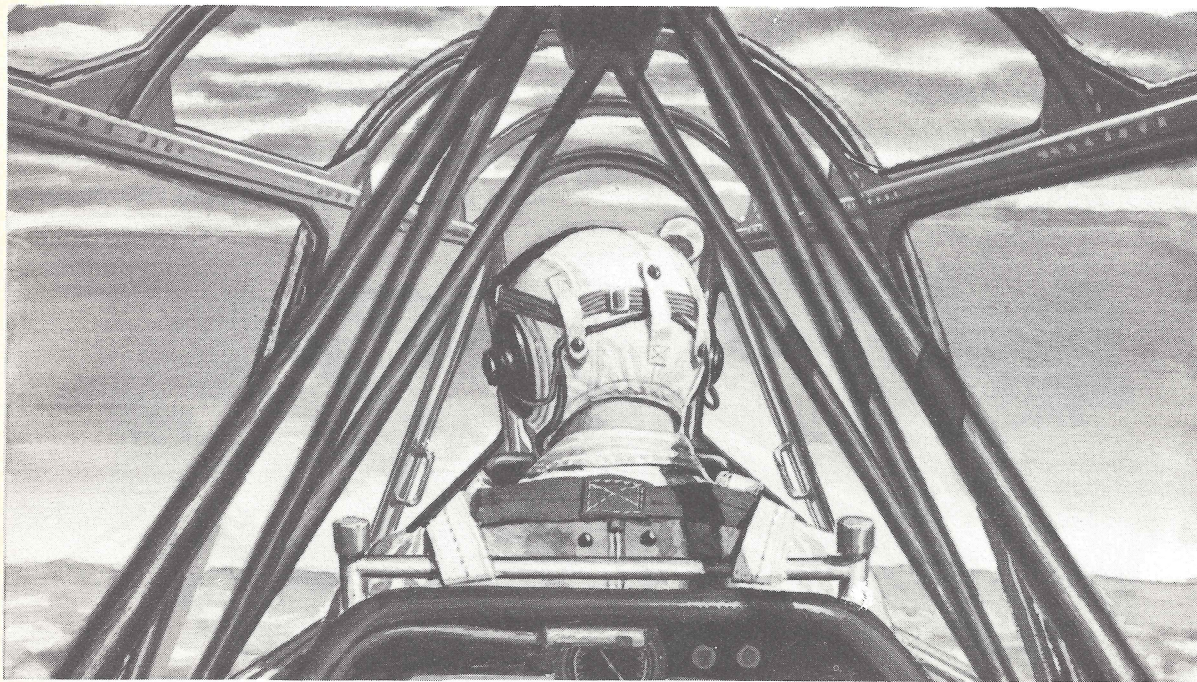
Mixture adjusted for smooth operation

Gear and flaps up

Attaining level flight, at first, is a matter of consciously fixing the relationship of reference points, on the aircraft with the horizon. These reference points will be used in varying degrees on all maneuvers and will continue to be your best aid for precision contact flying throughout your training. With the exception of the flight instruments, use of these reference points is the best method for instantly judging the attitude of the aircraft.

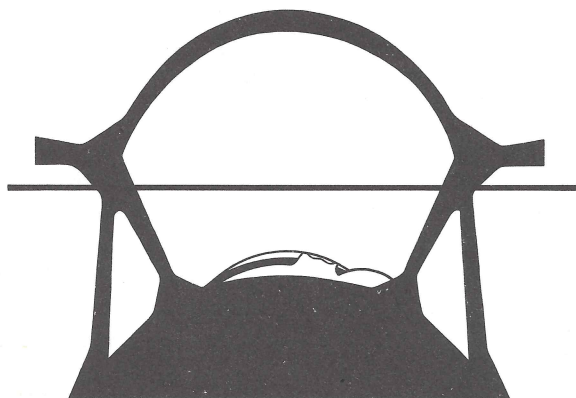
Initially, your instructor will establish straight and level flight and show you the visual reference points 360° around the cockpit so that regardless of where you look, you can accurately judge the attitude of the aircraft. It must be remembered that no two pilots will view these points exactly the same. The apparent position of the references will depend on how tall you are, and how and where you are sitting in the aircraft. So remember, it is important that you maintain your normal position at all times.

In the early part of your practice in straight and level flight, your instructor will empha-



size- maintaining constant flight attitudes through the use of visual references. But as you progress and become proficient in holding a constant attitude, he will also require you to hold a constant altitude. This will require you to use the altimeter as a check against your visual references to assure a constant altitude.

Level flight about the lateral axis (pitch attitude) is accomplished by selecting a point midway of the cowl and keeping it in a fixed position below the horizon. This is usually about six to eight inches below the horizon depending on your seated position. Forward- or back-stick pressure (elevator control) is used to control this attitude. There are many other visual references that may be used to judge

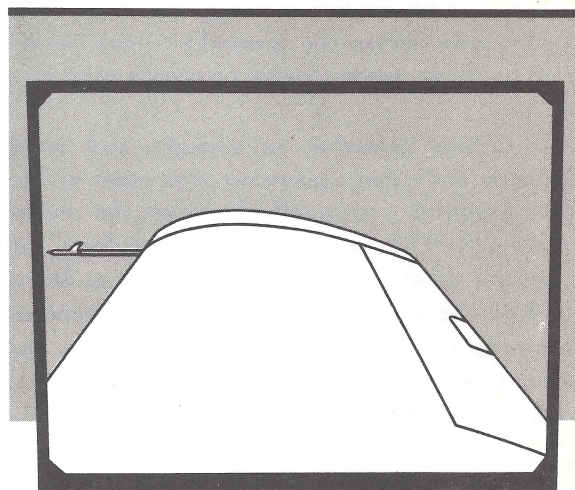


Nose Attitude for Straight and Level Flight

this attitude accurately. For instance, pitch attitude may be determined by the angle the canopy track and the wing tips make to the horizon. It can also be determined while looking back at the tail of the aircraft. The horizontal tail fins will be slightly below the horizon. Other visual references for pitch attitude will be pointed out by your instructor. In all normal maneuvers, the term "increase the pitch attitude" implies raising the nose in relation to the horizon; the term "decreasing the pitch attitude" means lowering the nose.

You accomplish level flight about the longitudinal axis (bank attitude) by visually check-

ing the relationship of the wing tips to the horizon. Both wing tips should be an equal distance below the horizon, usually about 24 inches. Your instructor may refer to



Wing Attitude for Straight and Level Flight

them as being equidistant. Side pressure on the stick (aileron control) is used to control this attitude. Other visual references may also be used to determine this attitude. For instance, the canopy track will be equidistant from the horizon, and the horizontal tail fins will be parallel to the horizon.

Even though there are many visual references that may be used to determine the bank attitude, the wing tips are the best because their use presents several other advantages. Other than being a positive check for bank attitude, looking at the wings helps divert your attention from the nose; this prevents a fixed stare and thus expands your area of vision. Check your wing tips frequently.

You achieve level flight about the vertical axis (yaw or directional control) by selecting a real or an imaginary point on the horizon directly over the nose of the aircraft. Left or right rudder pressure is used to control yaw.

As you look around and check your flight attitude, you will find many other references

that can be used to help judge directional control. For instance, roads and section lines on the ground offer excellent checks. You may fly straight along them, or you may fly parallel or perpendicular to them. (Wind drift, which will be explained later, will affect the track made across the ground.) Other points such as fields, towns, lakes, or clouds may also be used.

To attain precision in straight and level flight, or any other maneuver, you must divide your attention continually between the visual references. This is called "cross-checking" or "division of attention." The sooner you learn to look around and divide your attention properly, the sooner you will advance to another maneuver.

During your cross-check, occasionally include the altimeter to determine whether or not your pitch attitude is correct. If you are gaining or losing altitude, adjust your pitch in relation to the horizon and then re-check the altimeter.

CAUTION

Time spent looking in the cockpit is harmful to visual flying, especially in the early phases of your flight training. Spend as little time as possible checking your engine instruments, gas gauges, etc., but don't forget them. They must be checked periodically.

To establish straight and level flight from some other condition of flight, use smooth, even pressures on the controls and establish the proper flight attitude. While holding this flight attitude constant, adjust the throttle to 25" Hg and the propeller to 1850 RPM. Check to see that the gear and flaps are up. Adjust the mixture control for smooth, economical operation. Trim the aircraft so that the flight attitude will be maintained without any control pressures being applied. Check the gas gauges and put the selector on the fullest tank. During your cross-check, occasionally check the gauges and keep the gas tanks within ten gallons of each other.

After you have had a little practice in straight and level flight and have learned to check your visual references properly, you can establish the correct attitude in a matter of a few seconds. You will learn to look around quickly and to establish pitch, bank, and direction simultaneously. Power changes and trim technique will become second nature.

Tips

The relaxed weight of your right arm pulling against the stick may be sufficient to cause the ailerons to become slightly effective and result in "dragging a wing," that is, flying with one wing low. In most cases, this will result in a very slight turn to the right. To keep the aircraft from turning, left-rudder pressure would have to be used. This would set up an undesirable cross-controlled skid condition. Remember to check your visual references frequently, especially the wing tips, and this will never happen to you.

One of the most common faults of a student pilot is his tendency to stare at the nose of the aircraft and attempt to hold the wings level just by observing the curvature of the engine cowling in relation to the horizon. Of course, this cannot be done with any degree of accuracy and it may result in an appreciable dragging of one wing. As in the preceding paragraph, this attitude would require the use of additional rudder to maintain straight flight and would give a false conception of neutral control pressures and position. This is another case of what will happen if you don't look around properly.

Let your eyes rove all around the horizon and look for other aircraft that might be flying in your area while you check your visual references and orientation to the home field.

Straight and level flight requires almost no pressure on the controls, provided the aircraft is properly trimmed and the air is smooth. However, when the air is rough and you are flying through thermals of varying intensities, the flight attitudes may change with each "bump." Don't try to fight the controls to prevent these bumps from occurring. Just

make smooth adjustments in the flight attitudes as needed. Like driving over a very bumpy road, you can't keep the car from bouncing but you can keep it in your lane. When the air is extremely turbulent, reduce your flying speed and ride with the thermals just as you would reduce your automobile speed over an extremely bumpy road.

Things To Remember

Constantly cross-check all visual reference points.

Maintain a comfortable seating arrangement in the aircraft.

Watch for tenseness and gripping of the stick. If you find yourself becoming tense, take a deep breath and relax all over as you exhale.

Fly by pressures on the controls, and not movement of the controls. Apply the pressure smoothly and evenly. Later in your training you will learn that all flying is done in terms of "constants" — constant pressures on the controls, constant roll-in and roll-out of turns, constant rate of movement of the nose, etc.

CONFIDENCE MANEUVERS

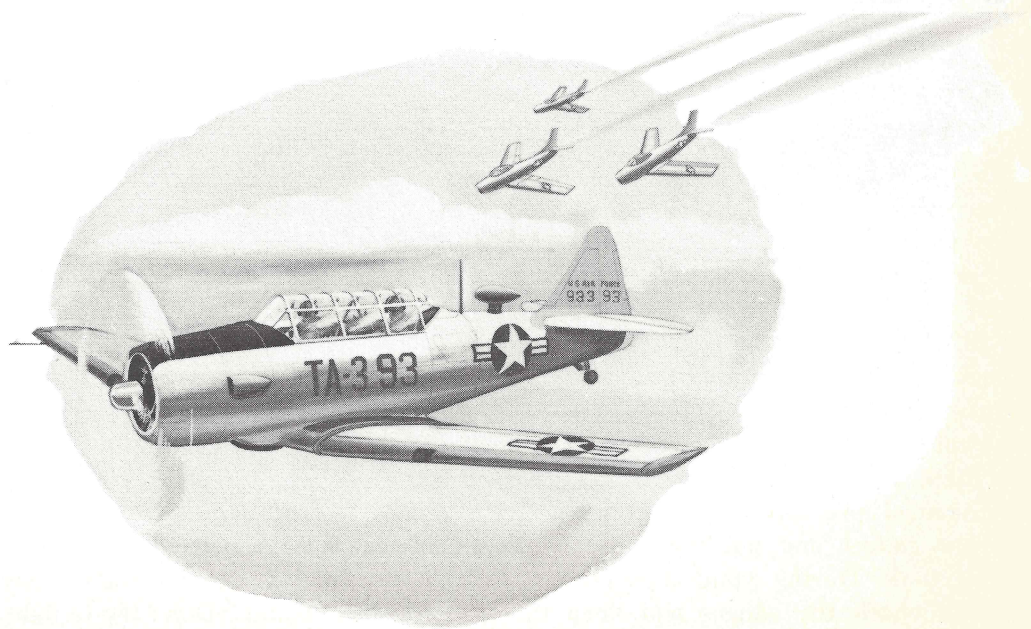
Up to this point you have been introduced to only the most basic of flight fundamentals. You have had a taste of flying, and this flying

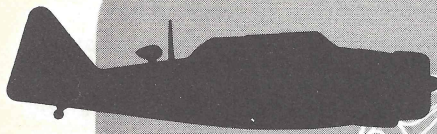
may have introduced a feeling of apprehension. This apprehension, if present, can be eliminated.

At the very beginning of your flight training, you will find that you are attempting to learn new principles and skills while you are in a new medium, or element. That is, before you began flying, most of your experiences were common ones: you walked down the street and felt the solid ground beneath your feet, you met people and talked to them, you saw large buildings and trees around you, or you sat in a chair on a solid, stationary floor.

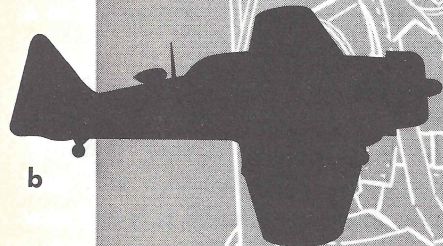
At first you may find it difficult to relax, but remember that a certain amount of anxiety is normal at this stage of your training. But with each succeeding day you will find yourself gaining more confidence in your new medium. Primarily, you will have to develop confidence in three things — the aircraft, your instructor, and yourself. You will generally find your confidence improving in these three in the same order that they are stated here.

First, you will gain confidence in the aircraft by learning the principles by which it flies. Also, as you gain experience, you will

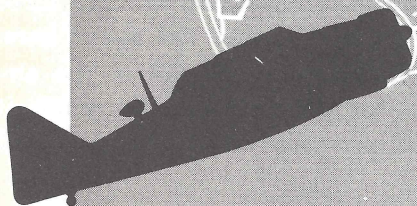




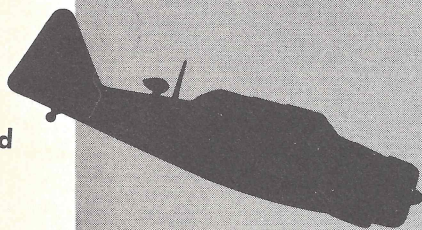
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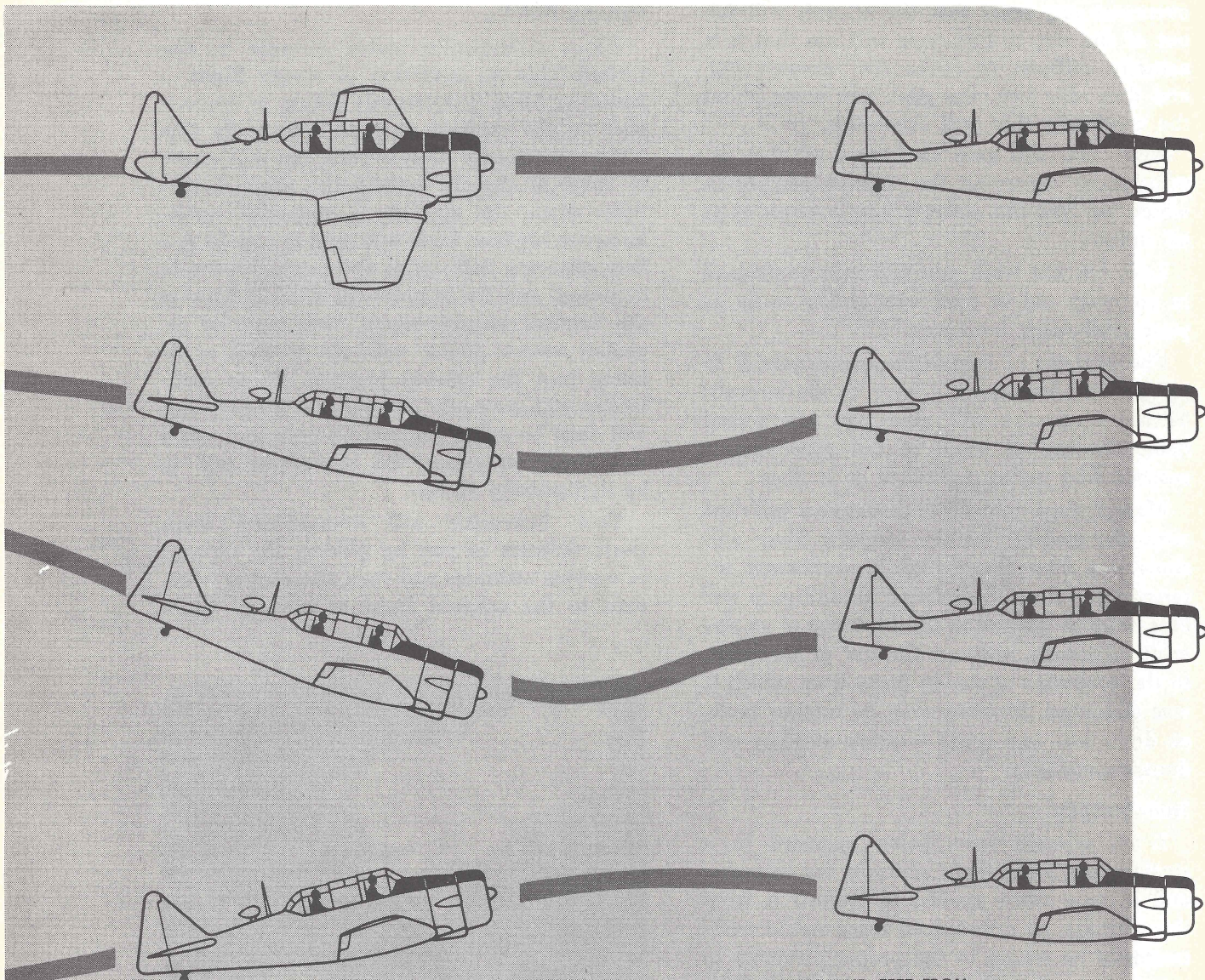
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Have Confidence in the Aircraft—It tends to fly by itself



- a. IN A LEVEL FLIGHT ATTITUDE — IF YOU REMOVE YOUR HANDS AND FEET FROM THE CONTROLS, THE AIRPLANE WILL TEND TO REMAIN IN THIS ATTITUDE.
- b. IN A TURN — IF YOU REMOVE YOUR HANDS AND FEET FROM THE CONTROLS, THE AIRPLANE WILL START A GENTLE DIVE AND EVENTUALLY RESUME LEVEL FLIGHT.
- c. FROM A CLIMBING ATTITUDE — IF YOU REMOVE YOUR HANDS AND FEET FROM THE CONTROLS, THE AIRPLANE WILL TEND TO RESUME LEVEL FLIGHT.
- d. FROM A DIVING ATTITUDE — IF YOU REMOVE YOUR HANDS AND FEET FROM THE CONTROLS, THE AIRPLANE WILL TEND TO RESUME LEVEL FLIGHT.

overcome any fears that the aircraft will fall out of the air; in fact, you will see that it is actually difficult to make the aircraft fall, and that only you, the pilot, can bring about the conditions that will cause this.

Next, you will gain confidence in your instructor by observing the positive manner in which he flies the aircraft and controls it at all times.

Last, but not least, you will gain confidence in yourself, and in your own ability to fly as your proficiency increases.

The purpose of confidence maneuvers is to aid you in developing a faith in the aircraft. These maneuvers will give you a practical demonstration of some of the aerodynamic reasons why an aircraft flies as it does.

Most of these confidence maneuvers will deal with the stability of the aircraft. They will show you how the aircraft is constantly attempting to keep itself flying. Stability, in our case, may be defined as the tendency of an aircraft to return, without the aid of the pilot, to the condition of steady flight from which it was disturbed. Stability may be further broken down into two types — static stability and dynamic stability.

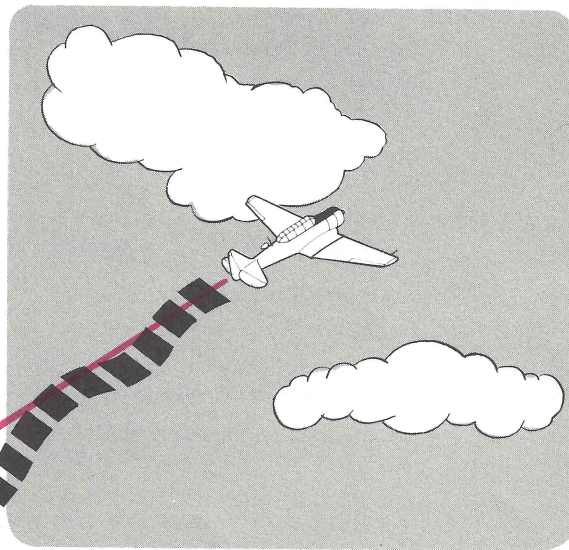
Static Stability

If an aircraft were being operated in a straight and level flight attitude, for instance, and a force were applied to disturb it from this attitude, an unbalanced force would automatically be set up in the proper direction to return it to the original attitude. If the aircraft tends to return to the original attitude, it is said to be statically stable.

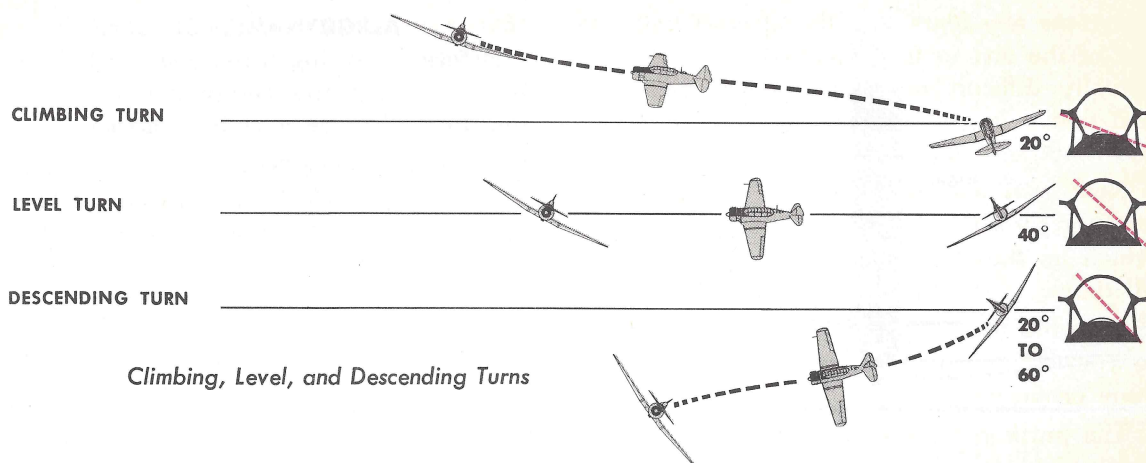
Dynamic Stability

When a statically stable aircraft is disturbed from its condition of steady flight, a restoring force is inherently set up to move it back to the original attitude. Ordinarily this force will not only carry it back, but will usually carry it slightly beyond the original attitude. Since the aircraft is statically stable, however, another force will tend to oppose this first restoring force after the original attitude is passed, and try to place the aircraft back to the original attitude again. This may be repeated several times, with the aircraft oscillating past the neutral position. These oscillations will gradually dampen out. The aircraft will then be in its original attitude and when this condition exists, the aircraft is said to be dynamically stable.

Your instructor will demonstrate these characteristics to you by placing the aircraft in various attitudes and then allowing it to return to the original flight attitude by itself.



Diminishing Oscillations Due to Stability



First he will trim the aircraft so it will fly in straight and level flight without any assistance from you or him. This is called "hands-off flight." Then he will exert a slight back pressure on the stick and cause the nose to rise slightly. At this point he will take his hands off the controls and tell you to do the same. Because of the construction of the aircraft with its inherent stability, the nose will begin to go down. It will continue on down to level flight, passing this position, and go slightly lower. The nose will remain in this position momentarily but will then begin rising again. It will rise to level flight and higher, but not quite as high as it was when he first established a nose-high attitude. These oscillations will continue several times, decreasing each time, until the aircraft is once again in straight and level flight. This is known as longitudinal stability.

The same thing would occur if the instructor had placed the aircraft in a nose-low attitude to begin with.

Next he will exert a slight side pressure on the stick which will cause one wing to lower. Both of you will then take your hands off the controls, and the wing will tend to return to the level attitude.

Your instructor will demonstrate directional stability next. He will apply pressure to one rudder pedal and then release the pres-

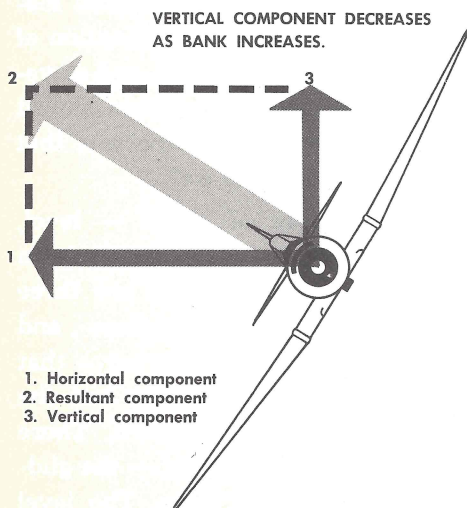
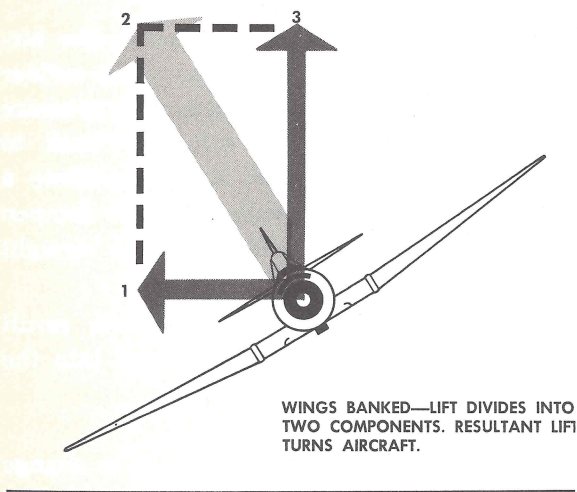
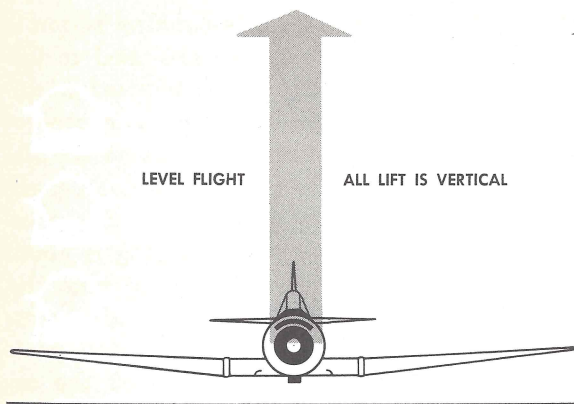
sure. When the pressure is applied, the aircraft will yaw in the direction of the rudder pedal that was depressed. When the pressure is released, the aircraft will yaw back to straight flight. Of course, it may oscillate a few times, but these oscillations will dampen out, and the aircraft will return to straight flight.

All of these conditions and effects result from the inherent stability designed into the aircraft.

URNS

A turn is a basic maneuver used to change the heading of the aircraft. It is probably the most complicated of all the fundamental maneuvers and involves the close coordination of all three controls — aileron, rudder, and elevator. Since turns are incorporated into almost all the other maneuvers, it is important that you be able to perform them well.

There are three types of turns — level, climbing, and descending — with variations in each of these. For instance, there are three classes of level turns — gentle-, medium-, and steep-banked turns. There are two turns that utilize a climb — the climbing turn and the maximum-performance climbing turn. There are two turns that utilize a descent — the gliding turn and the power let down. The level turns are the basic maneuvers and all other turns are variations of them.



Lift Components in a Turn

AERODYNAMICS OF TURNS

Before practicing turns you must thoroughly understand the aerodynamics that affect the aircraft while it is in a turn.

Lift Components of a Turn

Turns are made in an aircraft by banking. Banking causes the direction of the lift of the wings to move from the vertical to one side. This causes lift to pull the aircraft in the direction of the bank as well as continues to overcome gravity. This is done by using the ailerons to roll the aircraft in the direction that you desire to turn.

When an aircraft is flying straight and level, the lift component is acting perpendicular to the wings and the ground. As the aircraft is rolled into a turn, the lift divides into two components. One, the vertical component, acts perpendicular to the ground. The other, the horizontal component, acts parallel to the ground. These two lift components act at right angles to each other, causing a resultant lifting force to act perpendicular to the wings of the aircraft. It is this lifting force that turns the aircraft.

Loss of Vertical Lift

As the angle of bank increases, the vertical lift component decreases and the horizontal component increases; this causes the resultant lifting force to act more and more towards the horizontal component. Since the resultant lifting force acts more horizontally, the effect of lift acting vertically is decreased.

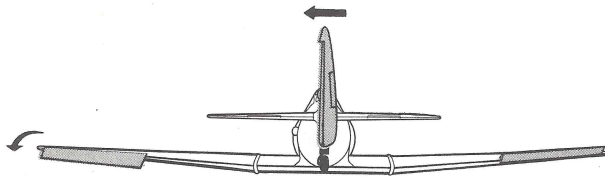
This loss of vertical lift causes the nose of the aircraft to become lower in relation to the horizon, and thus the aircraft loses altitude. As will be explained to you later, centrifugal force causes a similar effect on the aircraft.

When your aircraft is in a turn, you will find that a greater angle of attack is necessary to keep the nose from dropping and to prevent a loss of altitude. Increasing back-elevator pressure will keep the nose up. The steeper the angle of bank, the more back pressure you will have to use to keep the nose in the correct position. With an increase in bank and a greater angle of attack, the resultant lifting

force will be increased and the rate of turn will be faster.

Aileron Drag (Adverse Yaw)

Although it is aileron that causes the aircraft to roll, rudder must also be used to overcome aileron drag.



Rudder Overcomes Aileron Drag

In using the ailerons to effect a bank, the aileron on the higher wing is lowered and that on the lower wing, raised. The lowering of the aileron on the high wing causes greater drag than does the raised aileron. This occurs because the raised aileron is made less effective by the wing airfoil. The air that travels across the top of the wing moves a greater distance than does the air that travels across the bottom; this causes a difference in pressure on the two surfaces. When a turn is started, the aileron that goes down moves into an area of higher pressure than does the one that is raised. Although drag is exerted by both ailerons, the lowered one causes a greater amount. Thus, aileron drag tends to turn the aircraft toward the high wing (adverse yaw effect) while the banking action is taking place. After the bank has been established, the aircraft will start turning along its line of lift or in the direction of the low wing. The aileron on this wing is raised.

The amount of aileron drag depends on the extent of aileron displacement and the angle of attack of the wing. Aileron drag is most prominent at low speeds because the aileron displacement is great while the wing is at a high angle of attack. At high speeds the ailerons are more sensitive and are displaced a lesser amount; consequently, there is very little drag effect. At extremely high speeds aileron drag is not noticeable.

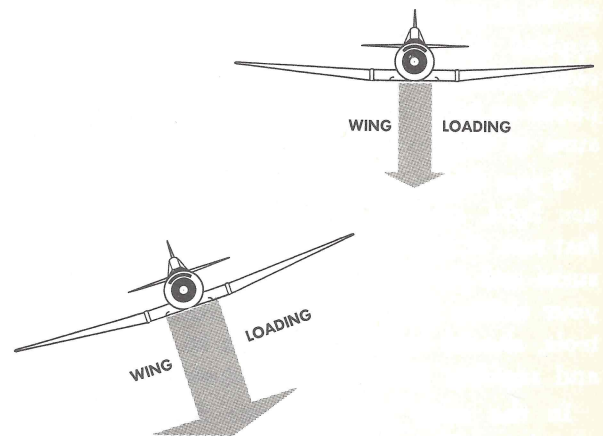
You must overcome aileron drag by using

the rudder. Use it as long as banking action is taking place. As the ailerons are used to initiate the turn, the rudder must be used simultaneously to overcome the drag. The correct amount of rudder pressure depends on the aircraft's speed and the amount of aileron used. At cruising speed in the T-6, the rudder pressure necessary to overcome the drag is about equal to the aileron pressure used; whereas, at lower than cruising speed, the rudder pressure must be greater than the aileron pressure. At higher than cruising speed the required rudder pressure is less than the aileron pressure.

Always remember to use the rudder and aileron pressures simultaneously, although the individual amount of pressure may differ depending on the effect of the drag. Also remember that aileron drag is just as effective during a recovery from a turn as from an entry, since aileron drag is also present during a roll-out.

Increased Load Factor (Wing Loading)

The wings of an aircraft in straight and level flight support a weight equal to the total weight of the aircraft and its contents. As long as the mass, or weight, of an aircraft is moving at a steady rate of speed and in a straight line, the load imposed on the wings remains constant. When the aircraft assumes



Centrifugal Force Increases Wing Loading as Bank Increases

a curved flight path, however, additional weight in the form of centrifugal force must be supported by the wing structure.

Anytime the aircraft is flying in a curved path the load supported by the wings is greater than the weight of the aircraft. This is true regardless of the plane of curved flight, i. e., whether the curved path is a level turn, a loop, or a pull-out from a dive.

As explained previously, a turn is produced by allowing the lift of the wing to pull the aircraft from its straight course while lift of the wing still continues to overcome gravity. Thus the wings must produce lift equal to the weight of the aircraft plus the centrifugal force caused by the turn. This can be done by increasing either the airspeed or the angle of attack.

Since increasing the airspeed when making a turn is impractical, the increased lift is obtained by applying a slight back-stick pressure to increase the angle of attack. This pressure must increase as the turn steepens and the centrifugal force builds up; it must be slowly released as the aircraft returns to level flight after the turn is completed. This procedure must be followed for all turns.

Governing the Speed of the Roll

When you use pressures on the controls, corresponding surfaces are moved into the air flow. This causes the aircraft to change its attitude in proportion to the amount of pressure applied and the duration of its application; consequently, the response of the aircraft depends on your ability to judge how much pressure to use on the controls.

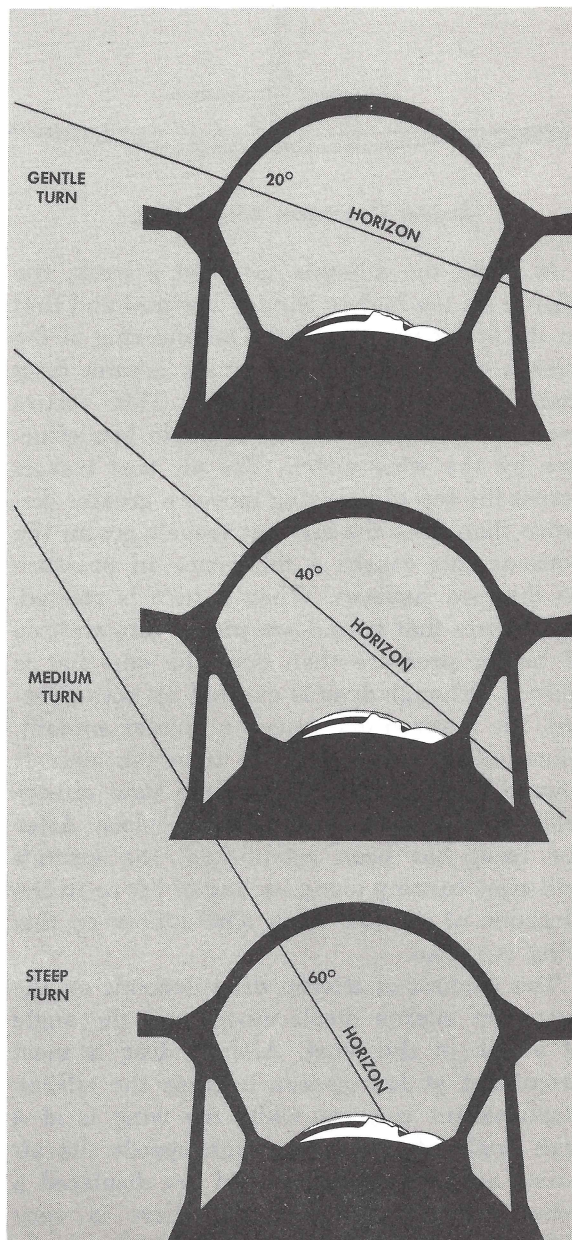
If you desire a slow rate of roll, you should use light, smooth pressures. If you desire a fast rate of roll, you should apply greater pressures and for a longer time. Pressure control, your ability to feel the pressures on the controls, should be in proportion to the amount and rapidity of the change desired.

In the early part of your flight training, practice rolling into your turns slowly until you have learned to feel the pressures properly. As your proficiency increases, you may roll

into the turns faster. This also applies to recoveries from turns.

GENTLE, MEDIUM, AND STEEP TURNS

Gentle, medium, and steep turns are the three level proficiency turn maneuvers. Since all other turning maneuvers are variations of



Nose Attitude in Gentle, Medium, and Steep Turns

these three, it is important that you learn to perform them well. Practice them at every opportunity.

The gentle turn is a shallow-banked turn and uses approximately 20° of bank. It is used for small corrections in heading, climbing turns, and power-on turning stall maneuvers.

The medium turn is the normal turn using approximately 40° of bank. It is used for large corrections in heading, clearing purposes, gliding turns, power-off turning stalls, and traffic pattern work. This turn will be used more frequently in your flight training than either of the other two.

The steep turn is one that uses approximately 60° of bank. It is for rapid changes of direction, clearing purposes, and precision maximum-performance maneuvers.

Since these maneuvers are executed from level flight, the conditions of flight are the same as straight and level flight. They follow:

Gyros caged for steep turns

Throttle at 25" Hg

Propeller at 1850 RPM

Mixture adjusted for smooth operation

Gear and flaps up

Normal cruising airspeed

Note: Since the first mention of "Gyros Caged" has been made in the conditions of flight at this point, a note of explanation should be added. It should be construed throughout the entire manual, that when the gyros are mentioned in the conditions of flight, they will be caged. If they are not mentioned, they should be uncaged.

Before beginning any turn, look in the direction of the turn to clear above, below, and at your flight level. You do this to make sure that the area is clear of other aircraft or clouds that may interfere with safely executing the maneuver.

When the area has been cleared, simultaneously apply pressure to both the stick (aileron) and rudder in the direction of the turn. This pressure will move the control surfaces out of their streamlined position and cause the aircraft to bank and turn. The rate at which

the aircraft rolls is governed by the amount of pressure applied. Hold these pressures constant until you get the desired amount of bank.

You will remember that during straight and level flight, the nose attitude was slightly below the horizon. As the bank is initially established to enter a turn, the nose of the aircraft should stay the same distance below the horizon that it was in level flight. As the bank increases, however, the pitch attitude will have to be increased to compensate for the loss of effective vertical lift and to overcome the effect of centrifugal force. In gentle and medium turns, the increase in pitch attitude is very slight. But, as the bank increases from medium to steep, the increase in pitch attitude becomes more pronounced.

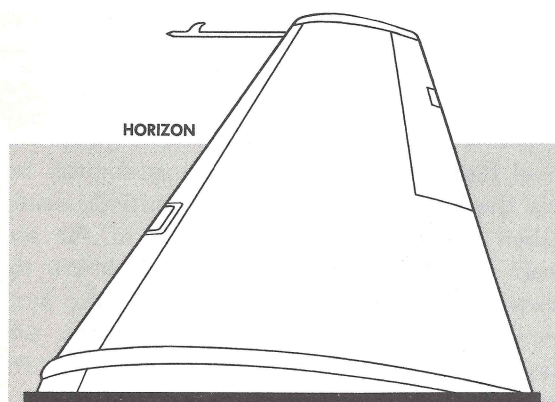
Just as in straight and level flight, visual references can be found 360° around the cockpit. However, the best visual references for the degree of bank will be found on the high wing.

For gentle turns, the horizon should intersect the aileron midway between the aileron trim tab and the inboard edge of the aileron.

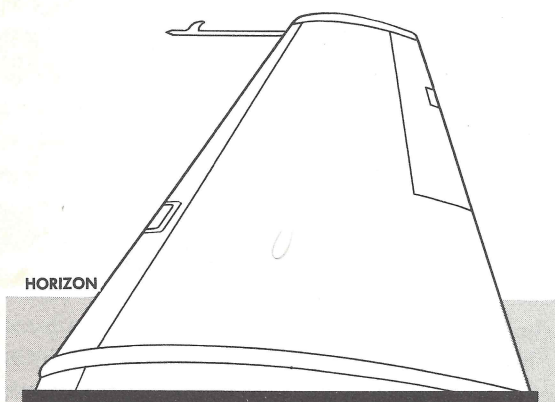
For medium turns, the horizon should intersect the leading edge of the wing approximately two-thirds the distance from the landing light inboard to the wing-root fairing.

For steep turns, the horizon should intersect the high wing slightly inboard of the wing-root fairing.

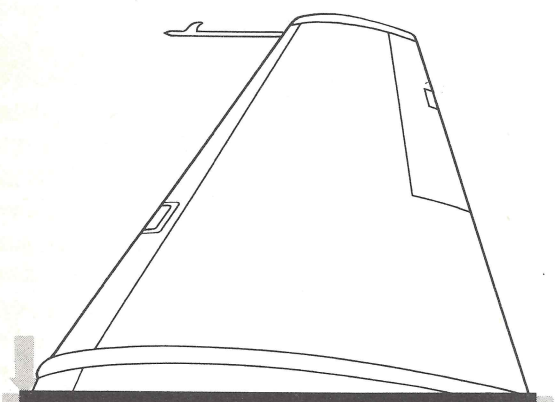
As the desired degree of bank is established, release the aileron and rudder pressures smoothly at the same rate that they were applied. This will stop the aircraft from continuing to bank, for the control surfaces will again become neutral; that is, they will be returned to their streamlined position again. The elevator pressure is not released but is held constant to hold a constant pitch attitude. Throughout the turn, the degree of bank should be held constant with the ailerons, just as the wings were kept level in straight and level flight. During steep turns, considerably more back-stick pressure is required to main-



GENTLE
TURN



MEDIUM
TURN



STEEP
TURN

Wing Attitude in Gentle, Medium, and Steep Turns
Note Reference Points

tain the pitch attitude than in gentle and medium turns.

Your recovery from a turn is the same as your recovery from an entry except that control pressures are used in the opposite direction. Apply aileron and rudder pressure in the direction of the rollout, that is, toward the high wing. As the degree of bank decreases, release the elevator pressure slowly and smoothly to hold a constant altitude. When you are no longer banking, the effect of centrifugal force and the loss of vertical lift are removed.

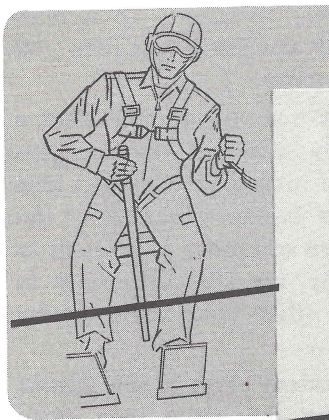
Since the aircraft will continue to turn as long as there is any bank, start the roll-out before reaching your desired heading. This will allow the aircraft to turn during the time it takes to roll the wings from a banked attitude to a level attitude. As the wings become level, release the pressures smoothly until the controls are all neutralized and the aircraft is again in straight and level flight.

Tips

Your posture while seated in the aircraft is very important in all maneuvers, especially in turns. Sit upright comfortably so that your body is equidistant from the wing tips. Don't lean your entire body forward or backward, or from side to side. Instead, move your head around freely.

During turns, continue to maintain this position. Don't lean away from the turn or attempt to keep your body vertical with the horizon. Relax and ride with the turn. If you don't maintain a relaxed, constant position in the cockpit, your visual references will change with every degree of change in bank. You will become tense and jerky on the controls. Remember, a relaxed pilot is a good pilot because he is free to think and can feel the pressures on the controls.

Plan all of your turns so that you make precision turns, that is, a constant degree of bank and a definite degree of turn such as a 90° , 180° , 270° , or 360° turn. To make a precision 90° turn, align the aircraft with a road or section line on the ground and turn perpendicular or parallel to it. In the absence of any



WRONG



RIGHT

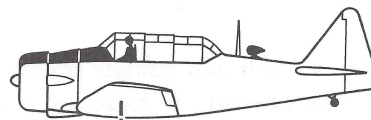
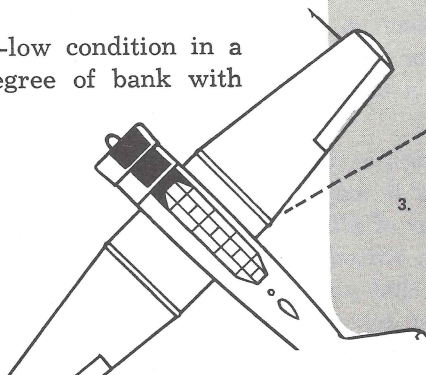
Sit Erect At All Times — Don't Lean Away from the Turn

ground reference, pick out a point of the horizon that is directly off a wing tip then turn to that point. This can be accomplished as you look around to clear the area. Remember, initiate the roll-out a few degrees short of your point so that when you get to the point your wings will be level.

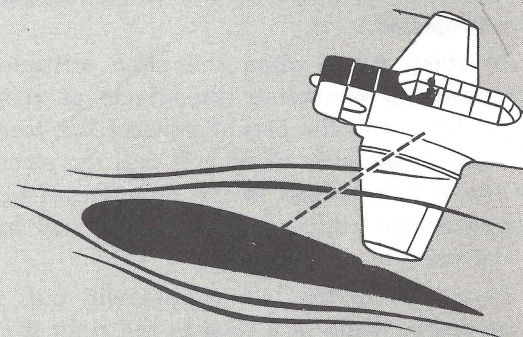
If the nose of the aircraft is allowed to drop during steep turns, do not apply back-stick pressure alone to raise it. If you do, a stall may result. Back-stick pressure causes the nose of the aircraft to come toward your face. In a steep turn, it would not pull it up toward the horizon line appreciably, but would pull it around the horizon, thus steepening the degree of bank and increasing the angle of attack.

To recover from a nose-low condition in a steep turn, reduce the degree of bank with

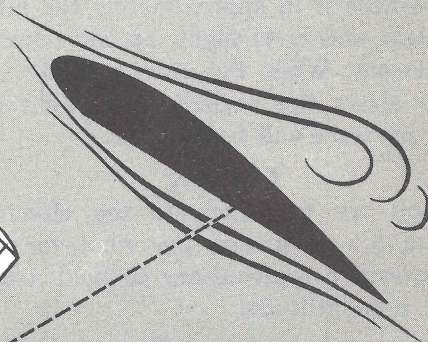
Increase of Angle of Attack in a Turn



1. Centrifugal force in a turn increases the wing loading as the angle of bank increases.



2. In order that lift be increased to equal added weight (wing loading) a higher angle of attack is needed. Back pressure on stick.



3. If too much back pressure is applied and the "Critical" angle of attack is reached, the wing will stall, just as in level flight.

coordinated aileron and rudder pressure. Then use back-stick pressure to raise the nose to the desired pitch attitude. After accomplishing this, re-establish the desired degree of bank. Don't try to make corrections solely with any one of the three controls. Use them together.

Torque and torque effects will be explained later in this chapter. You will learn that whenever an aircraft is being operated at a high power setting and a low airspeed, there will be a yawing effect present which will pull the aircraft to the left. In a steep turn the angle of attack will be higher than normal. This will cause the airspeed to decrease and the aircraft to yaw. This yawing is due to a torque effect caused by the asymmetrical loading of the propeller.

In steep turns when the pitch attitude is increased to overcome the effects of centrifugal force and the loss of vertical lift, torque will affect the aircraft. It will pull the aircraft to the left regardless of the direction of turn; consequently, right-rudder pressure will have to be used to overcome it.

In a turn to the left, torque will pull the nose down, while in a turn to the right it will pull it up. In both cases right-rudder pressure must be used when the nose is pulled to the left. In relation to the horizon the yaw attitude is increased or decreased.

If the nose is in approximately the attitude of straight and level flight, no correction will be necessary. When the pitch attitude is just slightly above the horizon, very light right-rudder pressure will be required.

CAUTION

Don't try to anticipate the effect of torque in a steep turn. Use whatever rudder pressure is necessary to hold a constant nose attitude.

After considering the effect of torque in steep turns, you can understand how it may, if not properly controlled, cause a loss of altitude in turns to the left and a gain in altitude in turns to the right. It is important that you understand the amount of effect that torque has on the aircraft. Actually, its effect is very

minor unless the pitch attitude is extremely high. It will, however, contribute to a false understanding of control pressures unless you are aware of its presence.

A common student misconception is that a steep turn is entirely different from a gentle or medium banked turn. This mistaken idea probably results from the fact that all of the aerodynamics of a turn are more prominent in a steep turn. Basically, the only difference in steep turns and the other level turns is the degree of bank.

A very common student error is the misuse of the controls during the entry to a steep turn. The aircraft must fly through a gentle and a medium turn before it reaches a steep turn. Some students apply the control pressures very rapidly and abruptly, using too much back-stick pressure before it is needed. This premature back pressure is sometimes caused by the natural tendency of the arm to move backwards as well as to the side.

You will find steep turns very easy if you will roll into them just as if you were rolling into a gentle and medium turn; then, simply continue to increase the back-stick pressure smoothly as the degree of bank increases.

Things To Remember

Always look around before starting a turn. Be sure that you are not turning into another aircraft or a cloud. Be relaxed. You will always fly better if you are relaxed.

Divide your attention between looking around and flying the aircraft.

Apply constant, even, coordinated pressures to the controls.

Maintain a constant rate of bank. If you do not attain the angle you desire, make slight positive corrections.

Anticipate the roll-in and roll-out of a turn so that you enter and recover from the turn at the exact desired point.

SKIDS AND SLIPS

In a perfectly coordinated constant bank turn, the aircraft makes a flight path which is a true circle with respect to the area of air

in which it is turning. In short, it has a constant radius of turn. (The flight path is not necessarily a true circle over the ground because of the effect of wind drift.) Any variation in its circular path results from uncoordinated control usage or erratic bank.

Skids

A skid occurs when the aircraft slides sideways away from the center of the turn. It is caused by too much rudder pressure in relation to the amount of aileron pressure used. In other words, if you try to force the aircraft to turn faster without increasing its degree of bank, the aircraft will skid sideways away from its radius of turn; that is, instead of flying in its normal curved pattern, it will fly a straighter course.

In a turn, the rudder must follow the flight path of the aircraft. If pressure is maintained on the rudder after the turn is established, a skid will result.

A skid may also occur when you are flying straight and level if the nose of the aircraft is allowed to move sideways along the horizon when the wings are level. This condition would occur when rudder pressures are held or when the aircraft is improperly trimmed.

Slips

A slip occurs when the aircraft slides sideways toward the center of the turn. It is caused by an insufficient amount of rudder in relation to the amount of aileron used. If you

roll into a turn without using coordinated rudder and aileron, or if you hold rudder against the turn after it has been established, the aircraft will slip sideways toward its center of turn. In other words, its circular path through the air will be more curved than it would be for a coordinated turn. It will fly in a tighter circle.

A slip may also occur in straight and level flight if one wing is allowed to drag, that is, flying with one wing low, and holding the nose of the aircraft straight by rudder pressure. In this case, the aircraft slips downward towards the earth's surface and loses altitude. A similar condition frequently occurs during straight glides, especially on the final approach to a landing glide.

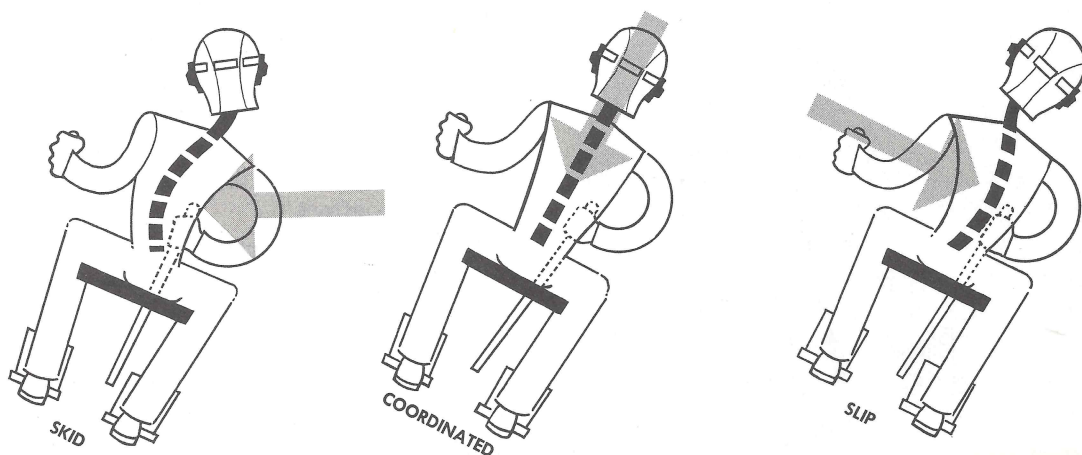
Tips

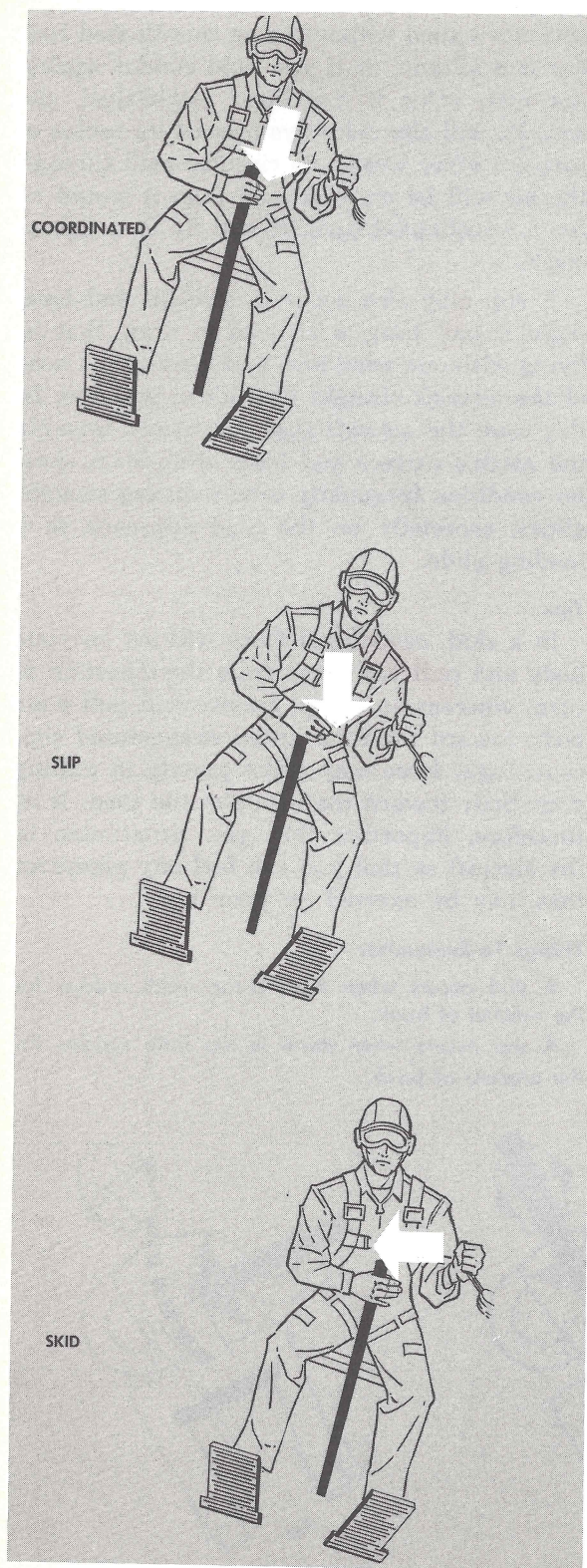
In a skid, centrifugal force will act on your body and pull you away from the direction of turn, whereas, in a slip, gravity will pull your body toward the turn. In an exaggerated slip, centrifugal force may assist gravity in pulling your body toward the inside of the turn. It is, therefore, important that you sit at ease in the aircraft so that you can feel any pressures that may be exerted on your body.

Things To Remember

A skid occurs when there is too much rudder for the amount of bank.

A slip occurs when there is too little rudder for the amount of bank.





TORQUE EFFECTS

Torque may be defined as the movements of a system of forces which tends to cause rotation. In short, torque produces or tends to produce torsion (act of twisting) or rotation. There are several cause-factors of torque that affect the aircraft during take-off and flight. They follow:

Gyroscopic action of the propeller

Asymmetrical loading of the propeller

Action of the corkscrewing slipstream on the vertical tail surfaces.

Torque reaction

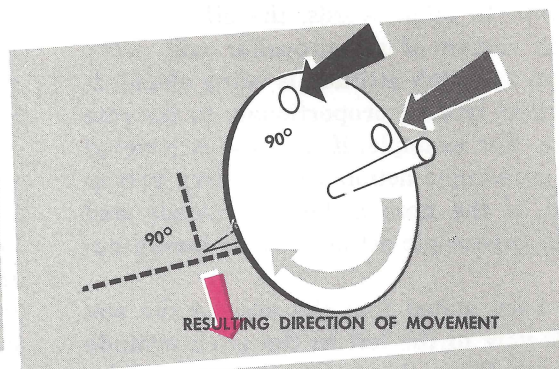
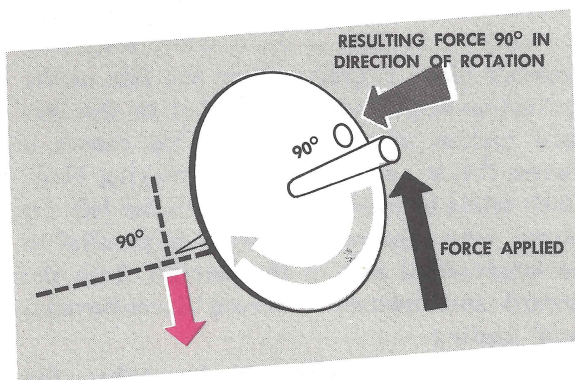
During flight these cause-factors will occur in varying degrees, depending on the conditions of flight. Cause-factors are interrelated to some extent; at least two of them will occur at the same time. Remember, however, that during different flight conditions, one cause-factor will have a more prominent effect than the others. Under one flight condition, asymmetrical loading of the propeller may cause the most prominent effect; under another flight condition, gyroscopic action of the propeller may cause the most prominent effect.

The four cause-factors of torque will be explained individually so that you may understand them and be able to make appropriate corrections. Since these effects are partially compensated for in the rigging of the aircraft, rigging will be explained later in this chapter.

Gyroscopic Action of the Propeller

Any spinning object exhibits gyroscopic properties. All practical applications of a gyroscope are based on two fundamental properties of gyroscopic action, — rigidity in space and precession. It is the precession property that we are concerned with in the explanation of the torque effect.

Precession is the resultant action or deflection of a spinning object when a deflective force is applied to the outer rim of its rotating mass. To apply a force to its axis, which runs through its center of rotation, is the same as to apply a force on its rim. When a deflective force is applied to the rim of a

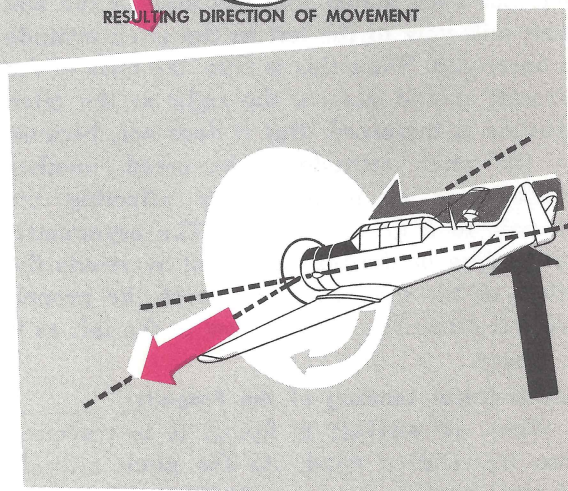


Gyroscopic Action (Precession)

rotating object, the resulting force is 90° ahead, in the direction of rotation, and in the direction of the applied force. In other words, the reaction of the force applied on the rim of a spinning object occurs 90° from where the force was actually applied or ahead one-fourth the distance of the circumference of the spinning mass. This causes it to move (precess) in the direction of, or away from, the resulting force.

To visualize this, imagine that you have a long piece of string and a top with a shaft running completely through it. (The shaft may be considered as the axis of the top.) Suppose you wind the string around the top so that when it is spun, it will spin to the right; that is, the rotation around its axis will be from left to right. Now spin the top on the floor directly in front of you.

As you face the spinning top, place one finger on the top of its shaft (axis) and push lightly straight ahead. If you do this, you will notice that the top did not move in the direction that you applied the pressure, instead it moved 90° from it, or to your left. When you tilt the top's axis toward your body, the top will precess to your right. You will also notice that the speed at which the top moves across the floor is directly proportional to the amount of pressure that is applied to its axis. For instance, if light pressure is applied, it will move slowly, and when strong pressure is applied, it will move rapidly.



The spinning propeller of an aircraft acts like a gyroscope and, like a gyroscope, it tends to precess if its axis is moved. During a change in pitch attitude, the axis of the propeller is moved, thus causing precession. Disregarding all other factors that act on the aircraft, the nose of the aircraft will yaw to the left when the pitch attitude is lowered and yaw to the right when the pitch attitude is raised. However, you will learn later that the nose of the aircraft will still yaw to the left when the pitch attitude is raised because another torque effect will become more prominent than gyroscopic action. So for all practical purposes, we will say that the gyroscopic action of the propeller is prominent only during decreases in pitch attitude. You will notice this particularly during take-offs and stall recoveries when the pitch attitude of the aircraft is being lowered.

The amount of precession is directly related to the speed with which you lower the nose of

the aircraft. In other words, the effect of the gyroscopic action of the propeller will occur *only* when the pitch attitude is being changed; and its effect will be proportionate to the rate of change. For example, if the nose is lowered rapidly, gyroscopic action will be very prominent and, if the nose is lowered slowly and smoothly, gyroscopic action may be barely noticeable.

It has been stated that the nose of the aircraft will yaw to the left as the pitch attitude is decreased. Since this is true, the nose of the aircraft should yaw to the right as the pitch attitude is increased. *But it does not*, because as the pitch attitude is increased, another cause-factor of torque starts affecting the aircraft to a greater degree. The asymmetrical loading of the propeller will overcome the effect of the gyroscopic action of the propeller and cause the nose to yaw to the left as it is raised.

Asymmetrical Loading of the Propeller

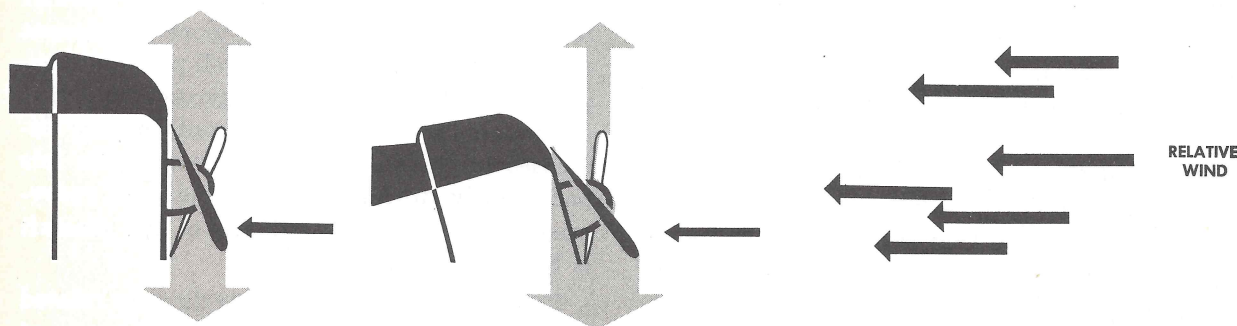
When an aircraft is flying, it is traveling into its relative wind. As the pitch attitude of the aircraft is changed, the angle of its relative wind also changes but to a lesser extent. That is, when an aircraft is flying in straight and level flight, its relative wind is parallel to the longitudinal axis of the aircraft; but when an aircraft is climbing, its relative wind is at an angle to the longitudinal axis. The angle of the relative wind increases as the pitch attitude is increased and as the airspeed decreases. It is the angle of the relative wind to the longitudinal axis that causes the asymmetrical loading of the propeller.

Asymmetrical loading of the propeller occurs because the bite of the downward-moving propeller blade is greater than the bite of the upward-moving blade, in relation to the forward motion of the aircraft. This causes a greater thrust on the downward-moving blade which tends to yaw the aircraft to the left. Of course, when the relative wind is parallel to the longitudinal axis of the aircraft, both the upward- and downward-moving blades have an equal loading.

The downward-moving blade strikes the area of greatest pressure when it is parallel with the lateral axis of the aircraft. When the forward speed of the aircraft decreases, the angle of the relative wind increases just as it does when the pitch attitude of the aircraft is increased. With this thought in mind, you can more easily understand that the effect of the asymmetrical loading of the propeller becomes more prominent as the pitch attitude of the aircraft is increased and/or as the airspeed decreases.

Action of the Corkscrewing Slipstream on the Vertical Tail Surface

The high-speed rotation of an aircraft propeller gives a corkscrewing rotation to the slipstream. This slipstream rotation travels clockwise around the fuselage as viewed from the cockpit. Part of it strikes the vertical stabilizer at a slight angle and exerts pressure on its left side; an equal part passes freely under the tail of the aircraft since there is no vertical fin to hinder it. It is the difference in these two pressures that causes the nose of the aircraft to yaw to the left. Although this

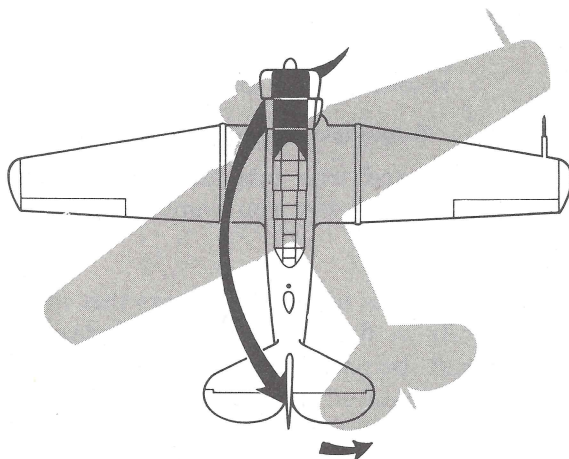
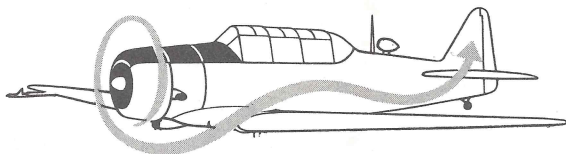


Asymmetrical Loading of Propeller

is not actually torque, we will consider it a cause-factor of torque since the slipstream has a torsional effect on the vertical tail surface.

Aircraft manufacturers have recognized this reaction and have corrected for it, to some extent, by offsetting the vertical stabilizer. The vertical stabilizer on the T-6 is offset one degree and forty-five minutes to the left of the longitudinal axis. This offsetting is called "rigging" and will be explained more fully later. The angle of the offset is measured from the leading edge of the vertical stabilizer.

This rigging neutralizes the yawing effect of torque at cruising speed. In all other conditions of flight, the tendency of the aircraft to yaw must be overcome by rudder pressure or trim. During rapid changes of power, rudder pressure must be used to overcome any tendency of the aircraft to yaw.



Slipstream Rotation

Torque Reaction of the Propeller

For every action there is an equal and opposite reaction. The rotation of the propeller, a clockwise movement as viewed from the cockpit, tends to roll the aircraft counter-clockwise, or to the left.

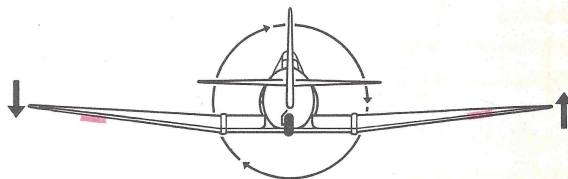
You can understand this by visualizing a rubber-band-powered aircraft. Wind the rubber band for right-hand propeller rotation, hold the propeller, and release the fuselage. The fuselage will spin around to the left.

This effect is present in any propeller-driven aircraft, except that the propeller, instead of being held still, is resisted by the air. This resistance tends to rotate the aircraft in the opposite direction from the direction of the rotating propeller.

On the T-6 aircraft the yawing effects of torque are compensated for at cruising air-speed by the offset of the vertical stabilizer. Since the wings of the T-6 are identical in design, control pressures and/or trim would have to be used to overcome any tendency of the aircraft to roll from this torque effect. The effect is most prominent during changes of power settings.

To compensate for this torque reaction, some aircraft are rigged in such a manner as to create more lift on the left wing than on the right wing. This is done by the left wing's being "washed in" (increased angle of incidence), and the right wing's being "washed out." Of course, these adjustments are made large enough to keep the aircraft balanced at cruising speed. Since this causes an undesirable stall characteristic of the aircraft, the T-6 aircraft is not rigged in this manner. It is rigged

GROUND ADJUSTABLE AILERON TRIM-TABS COMPENSATE FOR ROLLING TENDENCY.



Equal and Opposite Torque Reaction

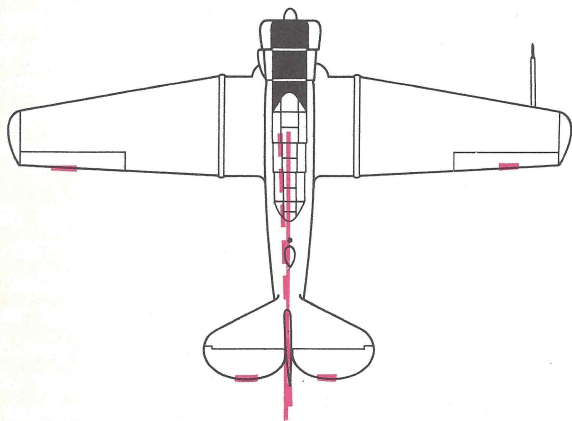
by use of ground adjustable aileron trim tabs.

Since both torque reaction and corkscrewing slipstream effect are most evident during similar conditions, your instructor will demonstrate them in various flight attitudes by making large abrupt power changes.

Rigging of the Aircraft

The vertical tail surface of the T-6 aircraft

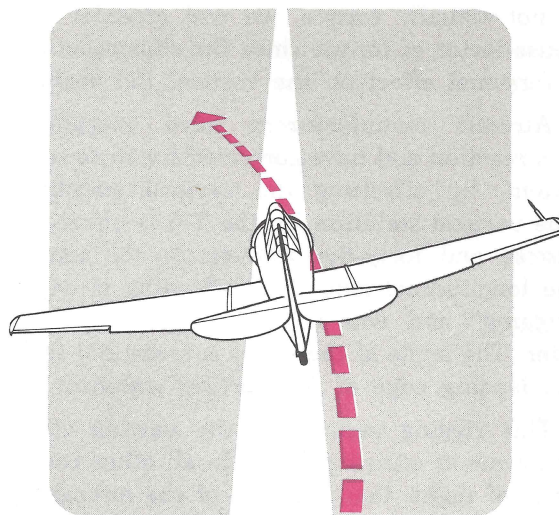
VERTICAL STABILIZER OFFSET $1^{\circ} 45''$ TO THE LEFT.



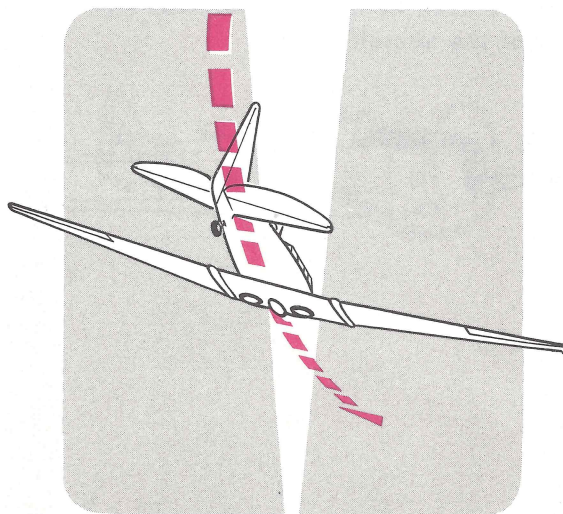
Rigging

is offset to the left one degree and forty-five minutes to compensate for torque effects at cruising speed. This was explained previously. During glides or maneuvers, when no power is being used and the effects of torque are minimized, the offset of the tail surface will tend to yaw the aircraft to the right. That is, since the offset of the vertical fin cannot be changed, the fin is continually attempting to compensate for torque although very little or none may be present.

For the same reason, when the aircraft is operated at higher than cruising speeds, as in high-speed dives, the offset tail surface will be more effective because of the greater volume of air passing over it. This will be more than is necessary to overcome the effects of torque and will again cause the aircraft to yaw to the right. So it must be remembered that although everything possible has been done to help you fly the aircraft, you must still use



OPENING THE THROTTLE CAUSES NOSE TO PULL UP AND TO THE LEFT



CLOSING THE THROTTLE CAUSES NOSE TO LOWER AND YAW TO THE RIGHT

Torque and Rigging Effects

the controls and trim tabs to make the aircraft perform the way you want.

Trim

When you sum up all the factors that affect the aircraft in flight, the need for trimming the aircraft becomes apparent. Considerable strength is required, for example, to hold the proper back-stick pressure in an untrimmed power-off glide. Flying would become exceedingly fatiguing if some means were not avail-

able to relieve the pilot of these pressures. By trimming the aircraft, you relieve yourself of extra physical exertion.

A trim tab is a small movable surface located on the outer edge of a control surface. Because of its location it has leverage and can be used to equalize the pressures exerted on either side of the parent control surface, that is, to streamline it for one condition of flight. Since it equalizes the pressure exerted on the parent control surface, it is always moved towards the side of least pressure or in the opposite direction from which the parent control is moved.

For example: Suppose that you are holding considerable back-elevator pressure in order to maintain a constant pitch attitude. In this

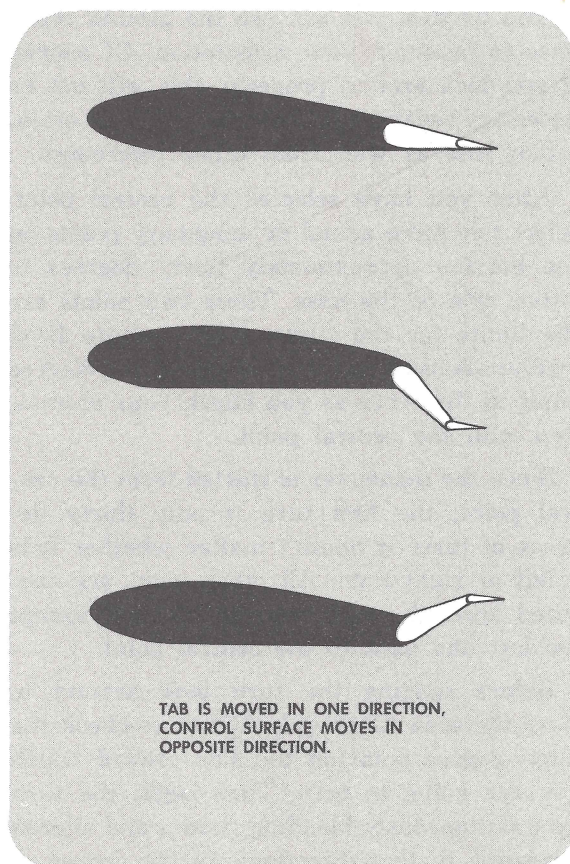
case the elevator would be in the raised position and the air pressure exerted on its top side would tend to push against it or try to return it to its streamlined position. To equalize this pressure the elevator trim control wheel, located in the cockpit, must be rolled back to the "tail heavy" position. When it is moved back the trim tabs will move downward and into the air flow across the bottom of the elevator thus causing pressure to be exerted against it. When the pressure exerted against it is equal to the pressure exerted against the raised elevator control, the aircraft will maintain its pitch attitude without any stick pressure. When this has been accomplished, the elevator is said to be properly "trimmed."

There is a trim tab on each of the control surfaces. Two of these, the elevator and rudder, are adjustable from the cockpit by a cable connection. The aileron trim tabs must be adjusted manually when the aircraft is on the ground.

The trim control wheels are located on the left side of the cockpit and consist of a rudder-trim and an elevator-trim control. To overcome yawing forces, adjust the rudder trim. To overcome pitch forces, adjust the elevator trim. Examples: In take-offs and climbs use right-rudder trim to compensate for the left torque yaw; in glides and power dives use left-rudder trim to compensate for right rigging yaw. To overcome excessive back-elevator pressure while maintaining an attitude, move the elevator-trim control to the "tail heavy" position. When the pressures on the controls have been neutralized, the aircraft is properly trimmed.

You will get a false "feel" on the flight controls if you do not constantly retrim the aircraft for each change in attitude. When extra pressures are needed on the controls to maintain a desired attitude, the aircraft needs retrimming.

The trim controls, properly used, are aids to smooth flying; misuse of the trim controls will result in flying that is inefficient and phys-



Trim Tabs and Control Surfaces

ically tiring. Anticipate the need for trim before take-off and when going around after an unsuccessful attempt to land. Remember, you must constantly retrim for each attitude by "feel."

Things To Remember

For all maneuvers not requiring abnormal attitudes of flight, first establish the desired attitude by exerting control pressures. Then adjust the trim to relieve all pressures from the controls so that the aircraft will hold this attitude. To check for proper trimming, take your hands and feet off the controls momentarily. The aircraft, if trimmed properly, should continue to fly at the same attitude.

Remember that the trim controls are on the aircraft in order to make it easier for you to fly. Use them.

COORDINATION EXERCISE

A coordination exercise is a precision maneuver consisting of a series of level medium-banked turns executed through thirty degrees of turn to each side of a central point. It is used to practice coordination of the control pressures in level turns.

This maneuver will increase your ability to remain oriented in turns, and will improve your planning and judgment in executing turns as well as improving your coordination. Your instructor will have you practice them while flying to the practice area, or to and from the auxiliary landing field.

Since a coordination exercise is a series of precision level medium-banked turns, it is necessary that you have a complete understanding of them and attain a fair degree of proficiency in their execution. Turns have been explained in detail earlier in this chapter. Study them thoroughly before practicing the coordination exercise.

Inasmuch as a constant altitude must be maintained in these maneuvers, the conditions of flight are the same as in straight and level flight.

Throttle at 25" Hg
Propeller at 1850 RPM
Mixture adjusted for smooth operation
Gear and flaps up
Cruising airspeed

To execute this maneuver, establish straight and level flight and trim the aircraft so that it will maintain its attitude without any pressure on the controls. Select a point on the horizon for the central point of the maneuver, then turn the aircraft so that the nose is directly beneath this point. This point may be an actual terrain feature, a cloud, or it may be imaginary. In your early practice of coordination exercises, it is well to first align the aircraft with a road or some prominent terrain reference so that the central reference point is directly over the nose of the aircraft. If you do this, you can use the ground reference to maintain your orientation. Of course, if you look around properly, this will not be necessary because you can maintain your orientation just as well from other references.

After you have selected the central point, select two more actual or imaginary points on the horizon approximately thirty degrees to either side of the nose. These two points are the limits for the turns. Now execute level medium-banked turns from one thirty-degree point to the other as you check your orientation with the central point.

Since the maneuver is started from the central point, the first turn is only thirty degrees of turn. It doesn't matter whether it is a left or right turn. All other turns are executed through sixty degrees of turn except the last one back to the central point.

Before starting the turn look around to clear the area thoroughly and to re-check the thirty-degree point on the side toward which you are going to turn. Then begin the turn by simultaneously blending rudder and aileron pressures in that direction. As the degree of bank increases, blend in back-stick pressure as needed to compensate for the effect of cen-

trifugal force and the loss of vertical lift in order to maintain a constant altitude. When the medium bank has been established, neutralize the aileron and rudder pressures smoothly and hold the degree of bank constant.

As you approach the thirty-degree point, start the roll-out so that the wings will pass through the level attitude just as the nose reaches the point. Don't stop the roll but continue banking to a medium-banked turn in the opposite direction.

This is a critical point in the maneuver because you must look around to clear the area before you enter the turn in the opposite direction, and also, you must vary the back-stick pressure to maintain a constant altitude. You will remember that during the roll-out from a turn, you release the back pressure smoothly because the effect of centrifugal force and the loss of vertical lift are gradually being removed until the wings become level. As the degree of bank increases from this point, back-elevator pressure must be re-applied as needed to maintain a constant altitude.

Continue making medium-banked turns

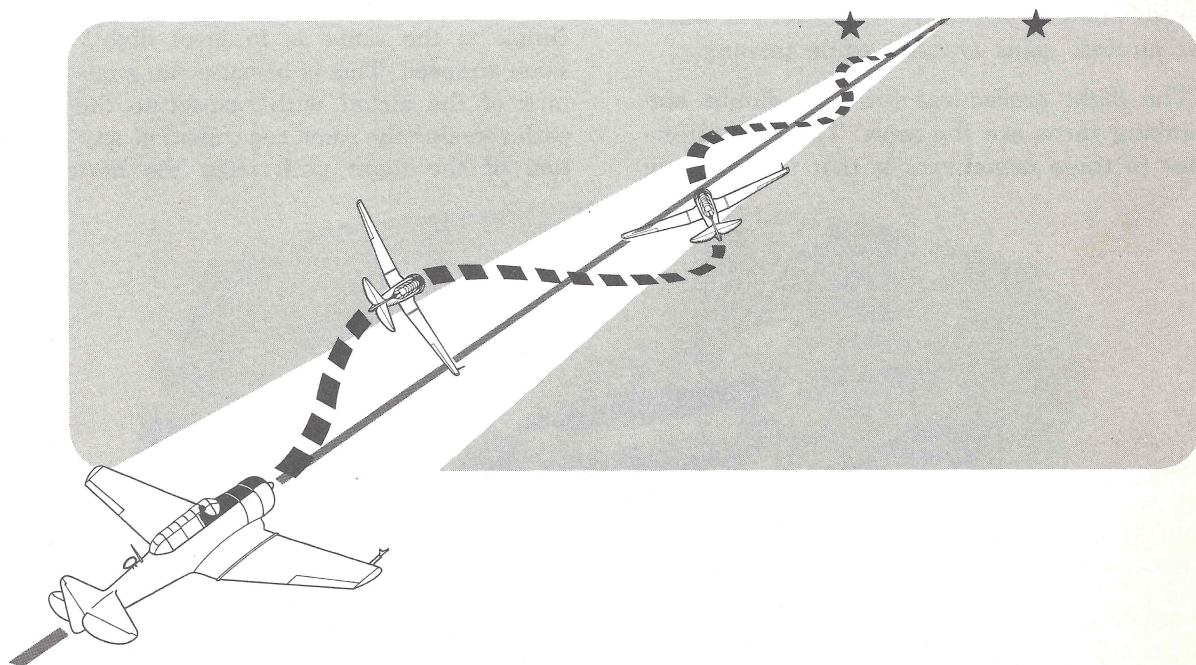
from one thirty-degree point through the central point to the other thirty-degree point. It is important that you keep the central point in mind at all times in order to maintain your orientation. Keep the rate of roll constant as you roll from one medium bank into another medium bank in the opposite direction.

The coordination exercise may be practiced as long as you desire.

Tips

Although this maneuver is normally practiced from level flight, it may be practiced from other attitudes as well. Your instructor may vary the maneuver to give you practice in some other particular attitude of flight such as a climb or a descent. The degree of bank may be varied from a shallow to a steep turn. The amount of turn may be varied to any degree but should be equidistant from a central point. If your coordination needs improvement in any attitude of flight, your instructor will change the coordination exercise to allow you practice in that particular attitude.

As you practice this exercise, do everything in terms of "constants." During changes of



Coordination Exercise

bank attitude, execute the rate of roll at a constant rate. While in the turn, maintain a constant degree of bank and keep the nose of the aircraft moving at a constant rate. Throughout the maneuver, maintain a constant altitude unless it is being practiced from a climb or a descent. In these cases, maintain a constant pitch attitude.

CLIMBS AND CLIMBING TURNS

Before practicing these maneuvers, you should have received instructions and practice in straight and level flight, level turns, confidence maneuvers, and taxiing. You should also have a fair degree of proficiency in control touch, coordination, and muscular sensitivity. Since torque becomes a primary factor in climbing turns, it is important that you review torque to refresh your knowledge of how it affects the aircraft.

Climbs and climbing turns are executed to gain altitude in a safe, orderly manner. Unless otherwise specified, a straight climb will be construed as that maneuver in which the aircraft gains altitude while traveling straight ahead. Climbing turns are maneuvers in which the aircraft gains altitude while turning.

The flight procedures for both climbs and climbing turns are the same. The only difference in these maneuvers is that the climbing

turn utilizes a gentle-banked turn. The conditions of flight are:

Throttle at 30" Hg

Propeller at 2000 RPM

Mixture for smooth operation

Gear and flaps up

110 MPH pitch attitude

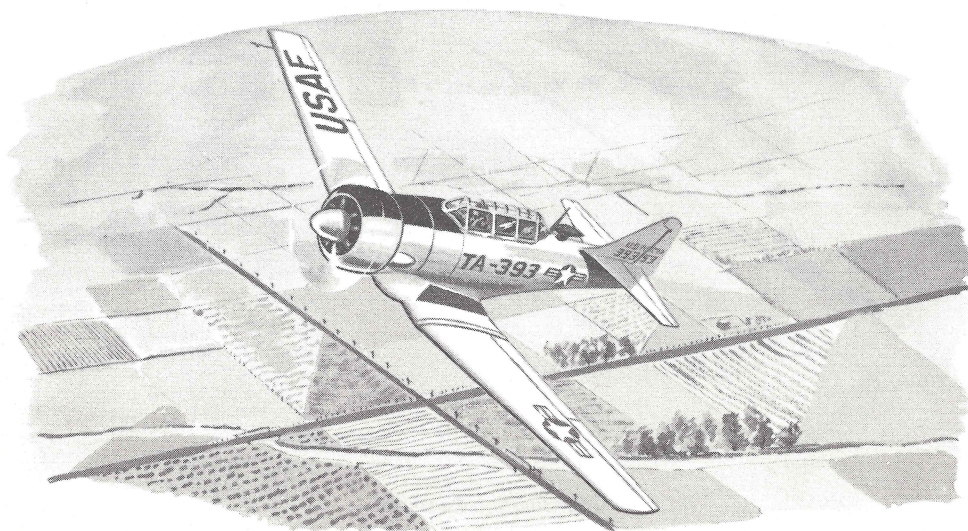
Gentle-banked turn (for climbing turns)

Since climbing turns will be most generally used, they will be explained in detail. About the only time you will utilize a straight-ahead climb is immediately after take-off. The straight-ahead climb after take-off will be explained more fully in the chapter on traffic patterns and landings. Climbing turns will be primarily explained in this particular section.

General Information

A normal climb is a climb made at an angle and speed which, when constantly maintained, will give the best altitude gain in feet per minute with the throttle set for climb power. This throttle setting varies with the type of engine and its installation, however, it is usually slightly above cruising but well below full throttle.

For all practical purposes the lift in normal climbs is the same as in level flight at the same airspeed. This is because the angle of attack of the airfoil with respect to the flight path remains the same regardless of any variation of the flight path from the horizontal.

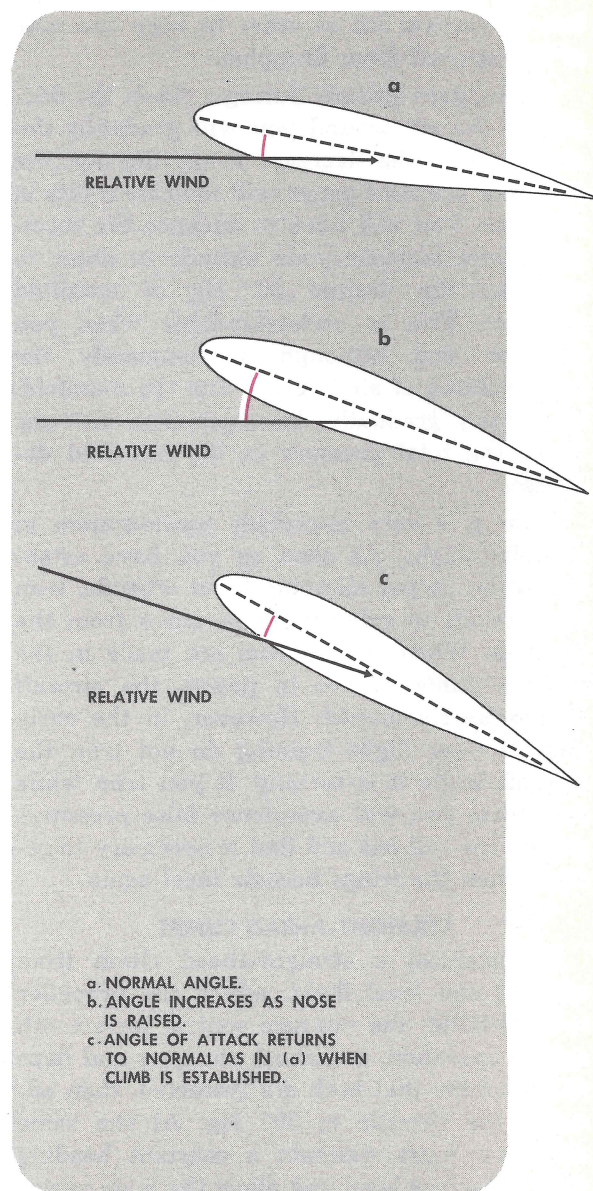


In going from straight and level flight to a climb, the forces acting on the aircraft go through definite changes with the change in attitude. The first change, lift, occurs when back pressure is applied to the controls. This change in lift is a result of the change in the angle of attack which occurs when the nose is raised. Momentarily, the lift, which becomes greater than the weight of the aircraft, forces the aircraft upward toward a higher altitude. The flight path is then inclined upward and as a result, the angle of attack and the corresponding lift again stabilize.

As the climb is started, the airspeed gradually diminishes. This change in airspeed is gradual rather than immediate because of the momentum of the aircraft. The thrust required to maintain straight and level flight at a given airspeed is not sufficient to maintain the same airspeed in a climb; therefore, climbing flight takes more power than straight and level flight. The best speed for a climb is somewhere between stalling speed and maximum-cruising speed. The speed for climbing flight in the T-6 aircraft is 110 MPH. Although this speed will not give you the absolute best rate of climb, it will give you a very satisfactory rate of climb, allow you better visibility, and provide better stability and control of the aircraft.

Torque is a primary factor to consider in climbs. Since the nose is well above the horizon and the airspeed is much lower than cruising speed, the angle of attack of the aircraft to the relative wind is relatively high. Under these conditions, the asymmetrical loading of the propeller will cause the aircraft to yaw to the left. To compensate for this torque yaw, right-rudder pressure or trim must be used. During the early practice of climbs and climbing turns, this may make your coordination feel awkward but after a little practice, torque correction will become natural.

All of the factors that affected the aircraft during level turns will affect it during climbing turns or any other turning maneuver. Because of the low airspeed, aileron drag (ad-



Angle of Attack in Climb

verse yaw) will have a more prominent effect than it did in straight and level flight; consequently, more rudder pressure will have to be blended in with aileron pressure in order to keep the aircraft in coordinated flight during changes in bank. Remember, additional back-stick pressure will have to be used to compensate for the effect of centrifugal force and

loss of vertical lift in order to keep the nose of the aircraft from dropping.

As you gain altitude during a climb, the density of the air around you will gradually decrease. With the decrease in air density, the manifold pressure gauge will indicate a loss in pressure. You will have to advance the throttle as you increase your altitude in order to maintain the desired 30" Hg of manifold pressure. This is understandable when you consider that although approximately the same volume of air is going into the manifold, its density gradually decreases with altitude. Thus, the total pressure in the manifold decreases.

Trim is a very important consideration in climbing flight. As soon as you have established the proper climbing flight attitude, trim the aircraft to relieve all pressures from the controls. When adjustments are made in the flight attitude and/or in power, the aircraft should be retrimmed. However, in the early part of your flight training do not trim the aircraft while it is turning. If you trim while in a turn, you will experience false pressures during the roll-out and find it necessary to retrim when the wings become level again.

STRAIGHT-AHEAD CLIMBS

To establish a straight-ahead climb from straight and level flight, adjust the propeller to 2000 RPM, the mixture control for smooth engine operation, and check the gear and flaps to determine that both are retracted, then advance the throttle to 30" Hg. At the same time you must maintain a constant heading with the wings level and allow the nose to rise to a 110-MPH climbing attitude.

NOTE

A change in power or airspeed will change the amount of downwash and the resulting amount of negative lift exerted by the horizontal stabilizers. As power and airspeed increase, downwash and slipstream velocity increase, thereby increasing the negative lift on the horizontal stabilizers and the positive lift of the wing. This causes the aircraft to assume

a nose-high attitude. If you desired to maintain straight and level flight, you would have to hold forward-stick pressure, or retrim the aircraft, as you increased the power.

The 110-MPH climbing attitude will be shown to you by your instructor and he will point out the visual references which you can use to determine it. The nose of the aircraft should appear above the horizon to the extent that the horizon line passes through the propeller hub. The wing tips should be equidistant below the horizon.

As the pitch attitude is being increased to the desired climbing attitude and as the airspeed dissipates, progressively more right-rudder pressure will have to be used to compensate for the asymmetrical loading of the propeller-torque effect in order to maintain directional control. Right-rudder trim should be used to relieve this pressure.

As the climb is established, back-stick pressure will have to be used to hold the pitch attitude constant. As the airspeed dissipates the elevators will try to return to their streamlined position. Elevator trim must be used to compensate for this so that the attitude may be maintained without holding pressure on the control.

After you have attained the proper flight attitude and airspeed, relax and look around. Although your visual references are different, maintain a constant cross-check on them just as you did while flying straight and level.

CLIMBING TURNS

During ground taxiing, you continually "S-turned" the aircraft so that you could see ahead. Because of the nose-high climbing attitude and the resulting poor forward visibility in climbs, you will have to clear ahead of your aircraft in much the same manner. This is accomplished by making turns. Since a prolonged straight-ahead climb might take you into the path of another aircraft, it is important that you always execute climbing turns on the way up to your practice altitude.

During turns the loss of vertical lift becomes greater as the degree of bank is increased; therefore, a gentle-banked turn must be used in order to maintain a good rate of climb. If a medium- or steep-banked turn were used, the aircraft would not climb as fast.

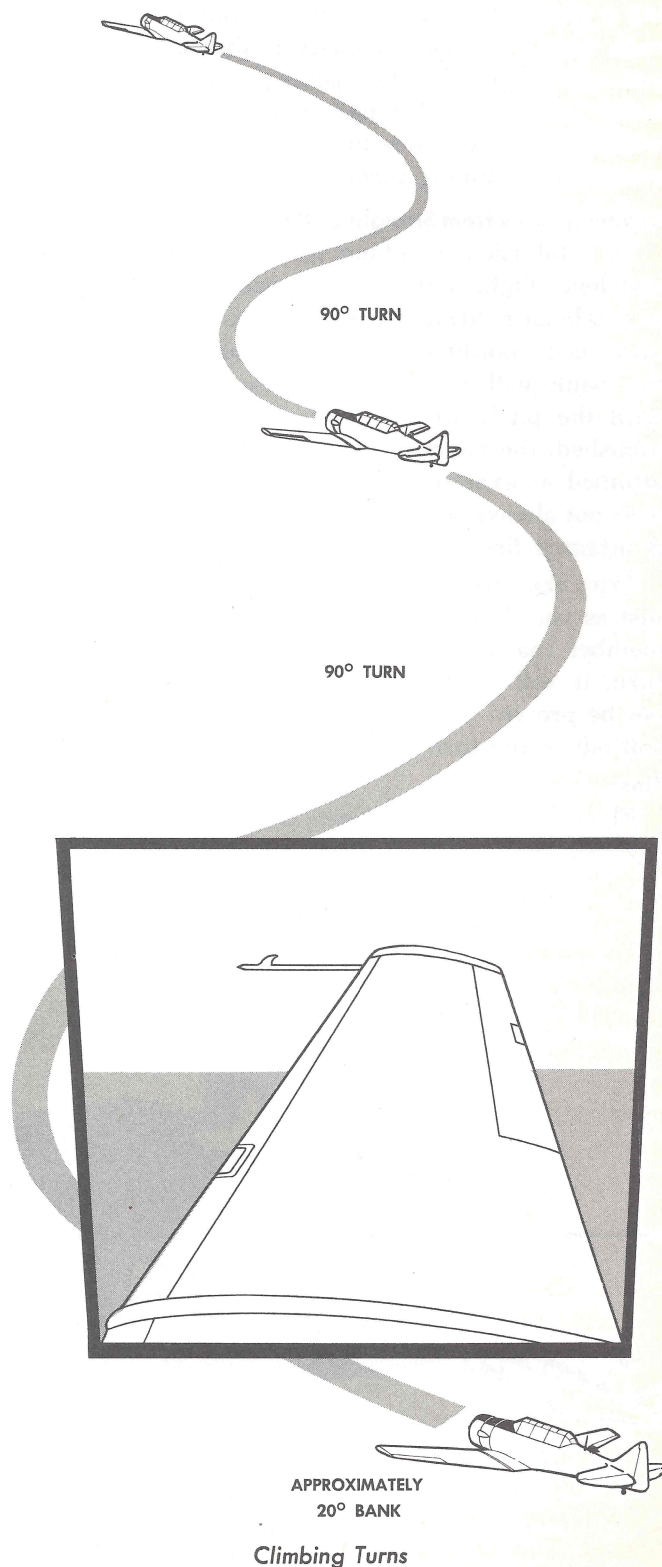
There are two ways to establish a climbing turn. You can first establish a straight-ahead climb and then execute the turn, or you can establish both the pitch and bank attitude simultaneously from straight and level flight. Since the first method is probably the easier, your instructor will have you practice it in the early part of your training. However, after you have attained a fair degree of proficiency in this method, he will require you to use the second method exclusively. This second method is the better because it allows you to clear the area as the climb is being established.

Climbing Turns from Straight-ahead Climbs

To establish a climbing turn from a straight-ahead climb, simply maintain a constant pitch attitude and smoothly roll into a gentle-banked turn just as you would from straight and level flight. The visual references for the degree of bank are the same. The horizon line should intersect the high wing approximately one-half the distance between the aileron trim tab and the inboard edge of the aileron. Except for the torque effect and increased aileron drag effect, a climbing turn is just like a gentle-banked level turn.

In order to make precision turns, align the aircraft with a road or section line on the ground and turn perpendicular or parallel to this line. In the absence of good section lines you may make precision 90° turns by selecting a point directly off one wing tip and simply turning to that point. This is a very good method because you will automatically clear the area in the direction of the turn when you select the 90° point. It should be combined with the ground reference method.

During the early part of your practice in climbing turns, make precision 90° turns as much as possible. Of course, clouds and other aircraft may at times prevent you from mak-



ing a precise 90° turn. In the beginning make each turn a separate maneuver, that is, after you roll-out on your 90° point pause momentarily before establishing another turn. This will allow you practice in entering and recovering from climbing turns.

Climbing Turns from Straight and Level Flight

To establish a climbing turn from straight and level flight, adjust the power as you did to establish a straight-ahead climb; but as the nose rises, coordinate control pressures so that the bank will be established simultaneously with the pitch attitude. If it is perfectly established, the pitch and bank attitudes will be attained at exactly the same time. Since this does not always occur, hold whichever one that is attained first and then effect the other.

Trim the aircraft as the turn is established just as you do in any maneuver. However, remember that if the aircraft is trimmed in the turn, it will compensate for factors that will not be present in straight climbs so when you roll out of the turn you will have to retrim.

Tips

Fly in terms of constants. Roll-in and roll-

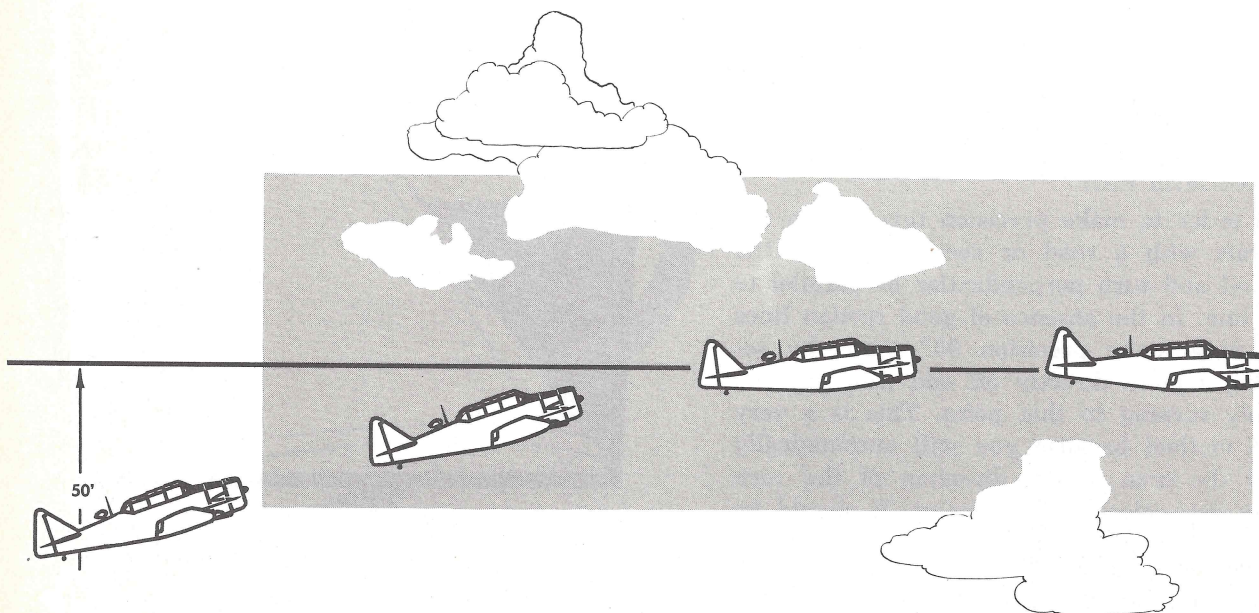
out of turns at the same smooth, constant rate. Maintain a constant pitch attitude and keep the nose moving around the horizon at a constant rate throughout the turns. Make precision, constant gentle-banked turns.

Hold a constant degree of bank with whatever aileron pressure is necessary. It is impossible to say whether the degree of bank will tend to increase or decrease; it depends on the rigging of the aircraft and the factors affecting the turn. The bank may tend to shallow because of the inherent stability of the aircraft, or it may tend to steepen because of the over-banking tendency of the aircraft and the effects of torque.

Things To Remember

In the beginning, hesitate after each climbing turn to check for proper attitude, airspeed, and power-setting, and to clear the area for the next turn. After the aircraft is properly trimmed for a straight-ahead climb, do not adjust it in the turn unless you are holding abnormal pressures.

Always sit relaxed in the aircraft so that you can feel the control pressures and maintain a constant cross-check of the visual references.



Level off from Climb

LEVEL-OFF FROM CLIMBS

To return to straight and level flight from a climbing attitude, start the level-out approximately 50 feet below your desired altitude. For example: If you are climbing to 5000 feet, start the level-off at approximately 4950 feet. When you approach this altitude, simultaneously level the wings and lower the nose to the level flight attitude. Lower the nose gradually, because a loss of altitude will result if you decrease the angle of attack to level flight without allowing the airspeed to increase proportionately. As the nose is lowered and the wings leveled, trim the aircraft.

When the airspeed builds up to approximately 130 MPH, reduce the throttle settings to 25" Hg and the propeller control to 1850 RPM and retrim the aircraft. After the aircraft is properly trimmed, check your gas and put the selector on the fullest tank. Adjust the mixture control for smooth engine operation if necessary.

DESCENTS

A descent is a maneuver in which the aircraft loses altitude while in a controlled attitude. It is also a maneuver in which the aircraft loses altitude at a controlled rate. There are two descending maneuvers that will be practiced as proficiency maneuvers in your primary flight training. They are the power let-down and the gliding turn. Later in the course you will be given dives as part of acrobatics and maximum-performance maneuvers. Before going into the study of these maneuvers, you must have a knowledge of how the forces acting on the aircraft affect its performance.

As in climbs, the forces acting on the aircraft go through definite changes when a descent is entered. When forward pressure is applied to the stick, the angle of attack is reduced and, as a result, the lift of the airfoil is reduced. This reduction in lift is momentary because, as in climbing flight, after the flight path changes, the angle of attack resumes the value of the straight and level condition. The change in the flight path is caused by the lift becoming less than the weight of the aircraft momentarily as the angle of attack is re-

duced. This unbalance of lift and weight causes the aircraft to follow a descending flight path with respect to the horizontal flight path of straight and level flight.

As the flight path changes to a descent, the angle of attack of the airfoil will again approach the original value and the lift and weight will stabilize. If the power (thrust) is not reduced, the airspeed will gradually increase as the descent is maintained. This is caused by a component of weight now acting forward along the flight path. The over-all effect is that of increased thrust, which in turn causes the increase in airspeed associated with descending at the same power as used in level flight.

For descents at the same, or lower airspeed than used in straight and level flight, obviously, the power must be reduced as, or before, the descent is entered. For this reason in both the power let-down and the glide, the power is reduced and the airspeed partially adjusted before the descent is started. In dives the power is left constant and the pitch attitude adjusted to attain an airspeed higher than cruising.

POWER LET-DOWN

A power let-down is a descending maneuver using a minimum power setting and maintaining a constant airspeed and pitch attitude. It is a maneuver that provides safe conditions of flight during descents in inclement weather or when close to the ground as the parasitic drag of the aircraft is at a minimum. Except for a reduced throttle setting and a lower pitch attitude, this maneuver is very similar to straight and level flight.

The power let-down is primarily used to descend to traffic altitude after upper air work has been completed. Plan the let-down so that you will be in position to enter the 45° entry leg of the traffic pattern.

There is no specified degree of bank or turn for this maneuver. Unless you are at a safe, high altitude, do not exceed a steep-banked turn, that is, approximately 60° of bank. As you descend, the degree of bank should be de-

creased to a maximum of approximately 40° of bank.

The conditions of flight for the power let-down are:

Throttle at 15" Hg

Propeller at 1850 RPM

Mixture adjusted for smooth operation

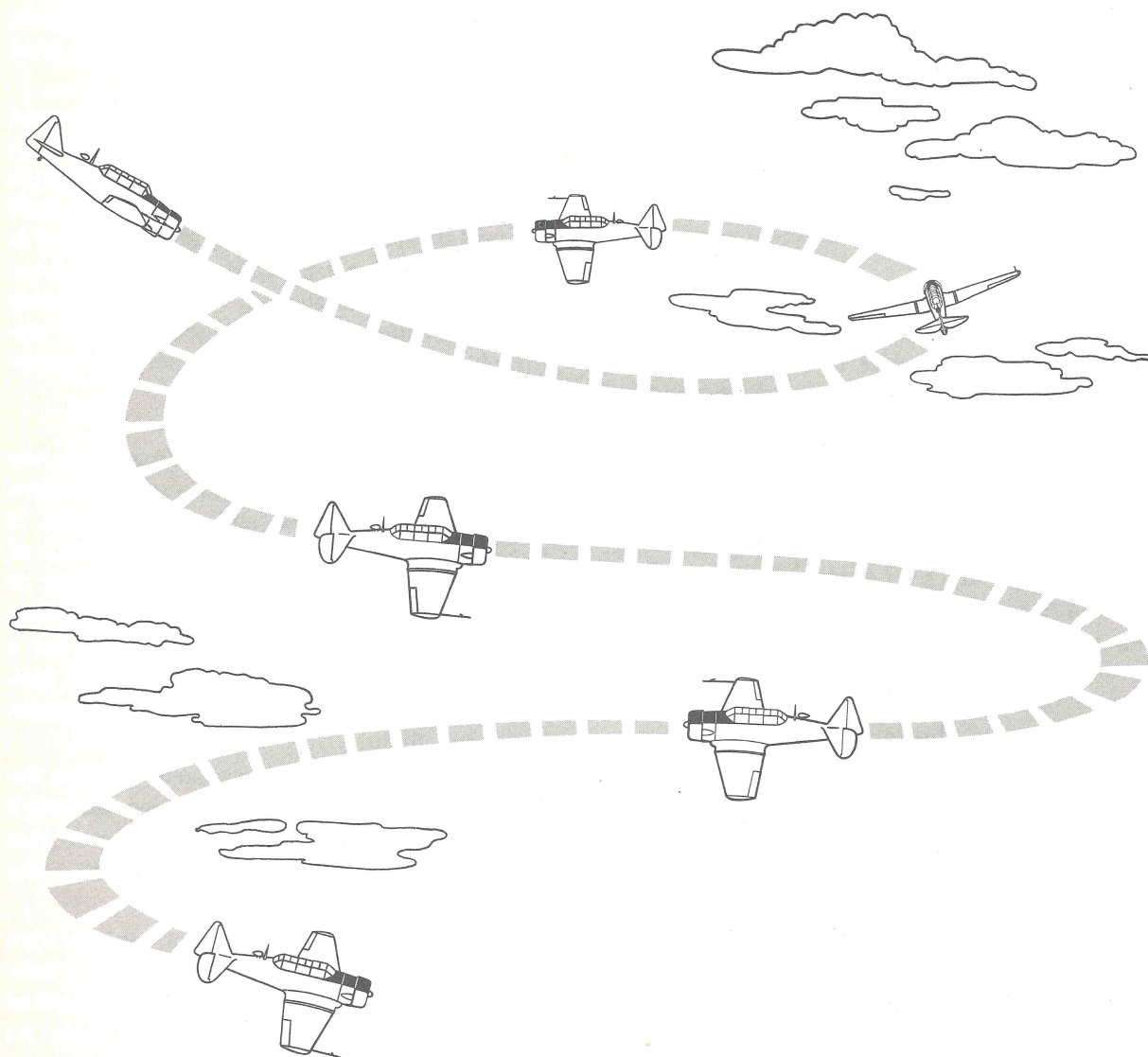
Gear and flaps up

Gas on fullest tank

Airspeed — 130 to 140 MPH

To establish this maneuver from straight

and level flight, reduce the throttle to 15" Hg and hold the pitch attitude constant until the airspeed dissipates to approximately 130 MPH. During the time interval the airspeed is dissipating, you should be trimming the aircraft. When the airspeed reaches 130 MPH, lower the nose attitude slightly to a descending 130- or 140-MPH attitude. This attitude and its visual references will be shown to you by your instructor. It is approximately two inches below the normal straight-and-level nose attitude. When this new attitude has been established, make the final adjustments in the trim.



Power Let-Down

After you have established the straight-ahead let-down, then make gentle-, medium-, and steep-banked turns in accordance with your preconceived plan to reach your desired position and altitude.

Tips

Remember that when you descend to a lower altitude, you descend into an area of higher air density. As the density of the air increases, the manifold pressure also increases and therefore you will have to continually retard the throttle to maintain 15" Hg of manifold pressure.

LEVEL-OFF FROM POWER LET-DOWNS

The level-off from a power let-down is very simple since the conditions of flight are so similar to straight and level flight. Approximately 50 feet above your desired level-off altitude, simultaneously level the wings, bring the nose up to level-flight attitude, and advance the throttle to 25" Hg. Since the power let-down airspeed is so close to cruising airspeed, it will be attained almost immediately; consequently, the aircraft can be trimmed very easily.

GLIDES AND GLIDING TURNS

A glide is the descent of an aircraft at a constant airspeed and attitude without power or with the throttle in the idling position. In this condition the weight of the aircraft is the primary moving force, and the path of the

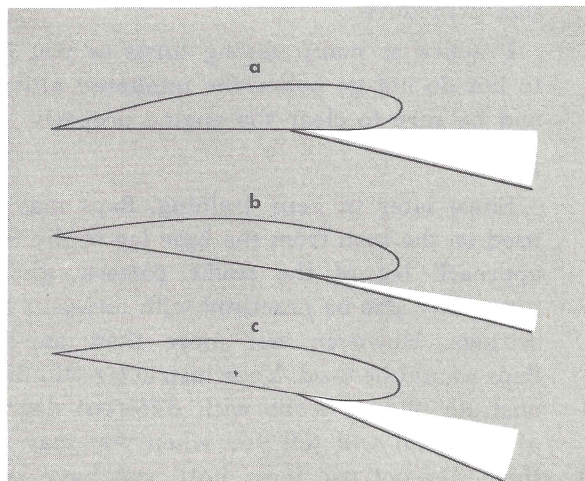
aircraft is downward as well as forward to maintain sufficient speed to give lift to the wings. A gliding turn is simply a turn made while the aircraft is in a gliding condition.

All practice of glides and gliding turns is, in the final sense, practice for the turn from the base leg to the final approach in the landing pattern. In fact, such turns could properly be called the "simulated final approach turn." Everytime you practice these turns, imagine that you are turning from the base leg to the final approach and concentrate on rolling out so that you will be lined up with a point as you would line up with the runway.

Glides and gliding turns are very necessary since they will be part of every normal landing pattern. Before you can progress to landing stages, it will be necessary for you to practice glides and gliding turns until you have absolutely mastered them.

Since gliding turns simulate part of the traffic pattern, the conditions of flight are very similar to the pre-landing procedure. They are:

- Throttle closed
- Propeller at 1850 RPM
- Mixture adjusted for smooth operation
- Gear down
- Flaps up (A maximum of one-half flaps may be used if desired)
- 100 MPH gliding attitude
- Medium-banked turn



a NORMAL ANGLE OF ATTACK

b ANGLE OF ATTACK DECREASES MOMENTARILY AS NOSE IS LOWERED FOR DESCENT.

c AFTER DESCENT IS ESTABLISHED, ANGLE OF ATTACK RETURNS TO NORMAL AS IN (a).

Angle of Attack in Glide

While flying straight and level, lower the gear with a normal check just as you would on the 45° entry leg of traffic. Check the propeller for 1850 RPM, throttle for cruising power, mixture control for smooth engine operation, and be sure that the flaps are up. Now imagine that you are on the base leg of a traffic pattern. At the simulated key position, close the throttle and maintain a constant altitude until the airspeed dissipates to 100 MPH. The left-rudder trim should be rolled back completely to mechanically trim the aircraft for the effects of rigging. In some aircraft this may not be enough trim to maintain straight flight; therefore, additional left-rudder pressure must be used. As the airspeed dissipates to 100 MPH, use the elevator trim control to help maintain the pitch attitude.

When the airspeed reaches 100 MPH, lower the nose to a 100-MPH pitch attitude. This may be checked by noting the position of the nose below the horizon. The airspeed indicator may be included in your cross-check to help determine the proper gliding attitude. Become familiar with the sound and feel of the aircraft in this attitude. It will help you to maintain the desired attitude.

After you have established the straight-ahead glide, select a road, section line, or some other prominent ground feature and line up with it. Look off to one side to clear the area, and select a section line or ground reference point 90 degrees from your present heading. Now execute a medium banked turn to a simulated final approach leg of a traffic pattern, and align the aircraft with the selected 90 degree ground reference point. In other words, line up with ground references and make 90 degree turns. Use smooth, coordinated control pressures.

As the angle of bank is established, you will notice that a slight amount of back pressure is necessary to maintain your attitude. Start your roll-out smoothly just before the nose reaches the 90° point and at the same rate you rolled into the turn. You should come back to a straight-ahead glide at exactly the 90° point.

Gliding turns should be practiced both to the left and right because your traffic patterns will vary in direction. Normally, gliding turns are practiced alternately from one direction to the other. After you have completed one gliding turn, take time to clear the area, re-check the attitude and airspeed, and then roll into a gliding turn in the opposite direction.

One noticeable effect in gliding turns that is not present in normal turns is that slightly more left-rudder pressure will be necessary in entries and recoveries to the left to overcome the rigging of the aircraft. For the same reason a smaller amount of rudder pressure is necessary in turns to the right.

The engine should be cleared at least every 180 degrees of turn or when the cylinder head temperature goes below 100 degrees centigrade. During cold weather, or at times when carburetor icing is anticipated, the engine should be cleared after each gliding turn.

To clear the engine, advance the throttle smoothly to approximately 25" Hg and simultaneously bring the nose of the aircraft up to the horizon. Hesitate in this attitude momentarily to make sure that the engine is cleared and operating properly. Then close the throttle and return the nose to the 100-MPH gliding attitude. Since the engine can be cleared fairly rapid, it will not be necessary to trim during this procedure.

Practice as many gliding turns as you like to but do not go below the minimum altitude and be sure to clear the engine properly.

Tips

Since later in your training, flaps may be used on the turn from the base leg to the final approach leg of the traffic pattern, gliding turns may also be practiced with different flap settings. However, not more than one-half flaps should be used. Your instructor will demonstrate gliding turns with different degrees of flaps and will tell you when you may use them. Do not use them until you have been told to by him.

Things To Remember

Always maintain a constant attitude. Fly the aircraft by attitude and use the airspeed indicator only as a check.

Try to develop a "feel" for the glide. You will find after some practice, that you can maintain the attitude almost by "feel" alone.

Just as in level turns, always maintain a constant angle of bank in gliding turns.

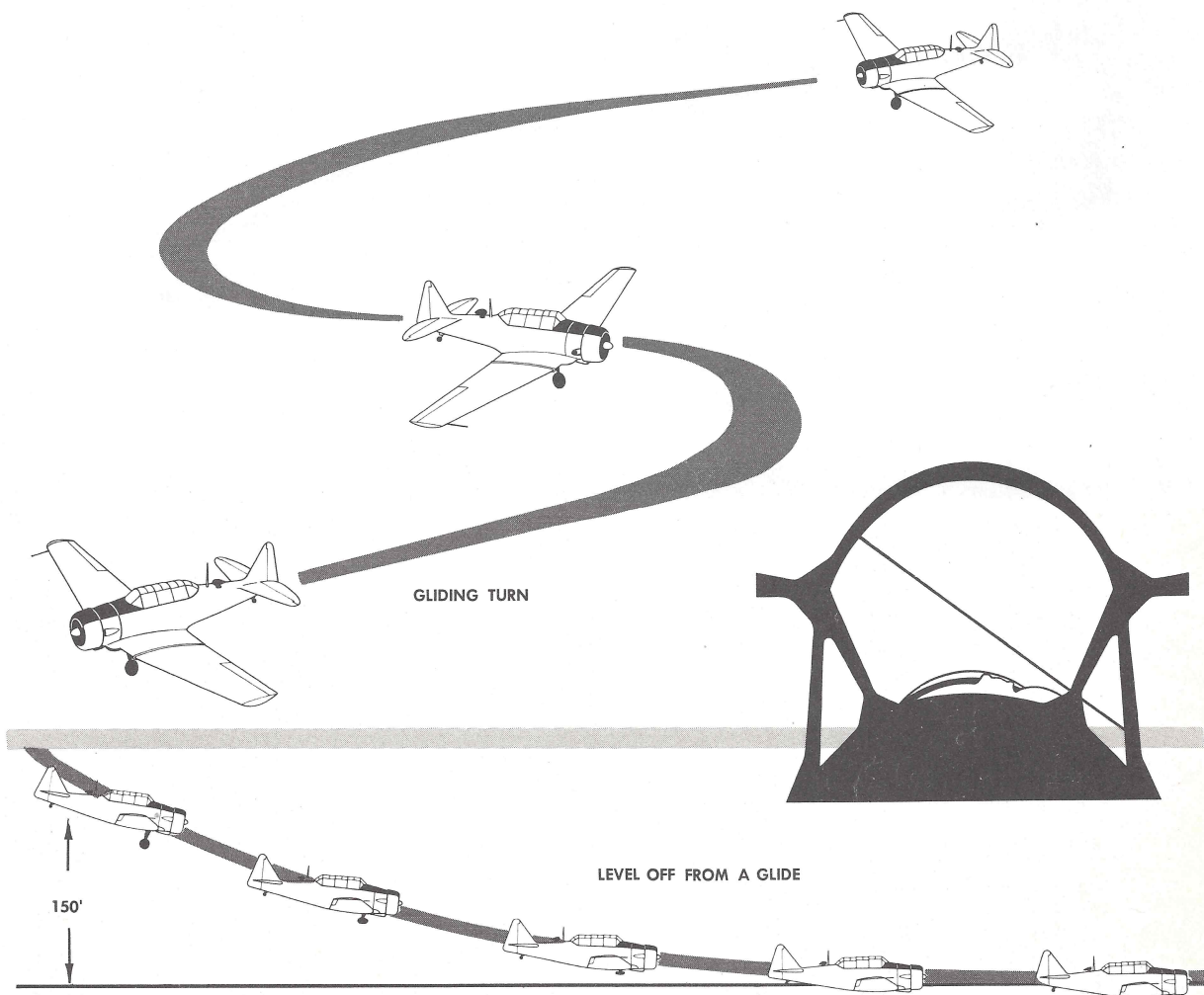
Make each of your turns a full 90° . Plan your roll-out so that you are back to straight flight at exactly 90° from where you rolled into the turn.

Remember, more rudder pressure is required to make good gliding turns than to make level turns because of the rigging of the aircraft and a more prominent aileron drag effect.

Always clear the engine at least once for every 180° of turn.

LEVEL-OFF FROM GLIDES

A level-off from a glide is very similar to a level-off from a power let-down except that there is more procedure to accomplish. At approximately 150 feet above the desired level-off altitude, advance the throttle smoothly to 25" Hg and retract the gear. (Also the flaps, if they have been used.) Then bring the nose of the aircraft back to the straight and level cruising attitude, just as you did during the level-off from power let-downs, and retrim the



aircraft. During this procedure the aircraft will descend approximately 150 feet as the airspeed builds to cruising speed. You should arrive at your desired level-off altitude with approximately cruising airspeed.

The power let-down is used to descend from the minimum gliding turn altitude, to the traffic pattern, after the level off from the glide has been accomplished. Before entering the

power let-down, and before descending below the minimum altitude used for gliding turns, check the following:

Mixture rich

Gas on fullest tank (Rt or Res)

Canopy open

You are now ready to retard the throttle to 15" Hg. and enter a power let-down to the traffic pattern.

