NORMAL APPROACH AND LANDING

A normal approach and landing involves the use of procedures for what is considered a normal situation; that is, when engine power is available, the wind is light or the final approach is made directly into the wind, the final approach path has no obstacles, and the landing surface is firm and of ample length to gradually bring the airplane to a stop. The selected landing point should be beyond the runway's approach threshold but within the first one-third portion of the runway.

The factors involved and the procedures described for the normal approach and landing also have applications to the other-than-normal approaches and landings which are discussed later in this chapter. This being the case, the principles of normal operations are explained first and must be understood before proceeding to the more complex operations. So that the pilot may better understand the factors that will influence judgment and procedures, that last part of the approach pattern and the actual landing will be divided into five phases: **the base leg, the final approach, the roundout, the touchdown,** and **the after-landing roll**.

It must be remembered that the manufacturer's recommended procedures, including airplane configuration and airspeeds, and other information relevant to approaches and landings in a specific make and model airplane are contained in the FAA-approved Airplane Flight Manual and/or Pilot's Operating Handbook (AFM/POH) for that airplane. If any of the information in this chapter differs from the airplane manufacturer's recommendations as contained in the AFM/POH, the airplane manufacturer's recommendations take precedence.

BASE LEG

The placement of the base leg is one of the more important judgments made by the pilot in any landing approach. [Figure 8-1] The pilot must accurately judge the altitude and distance from which a gradual descent will result in landing at the desired spot. The distance will depend on the altitude of the base leg, the effect of wind, and the amount of wing flaps used. When there is a strong wind on final approach or the flaps will be used to produce a steep angle of descent, the base leg must be positioned closer to the approach end of the runway than would be required with a light wind or no

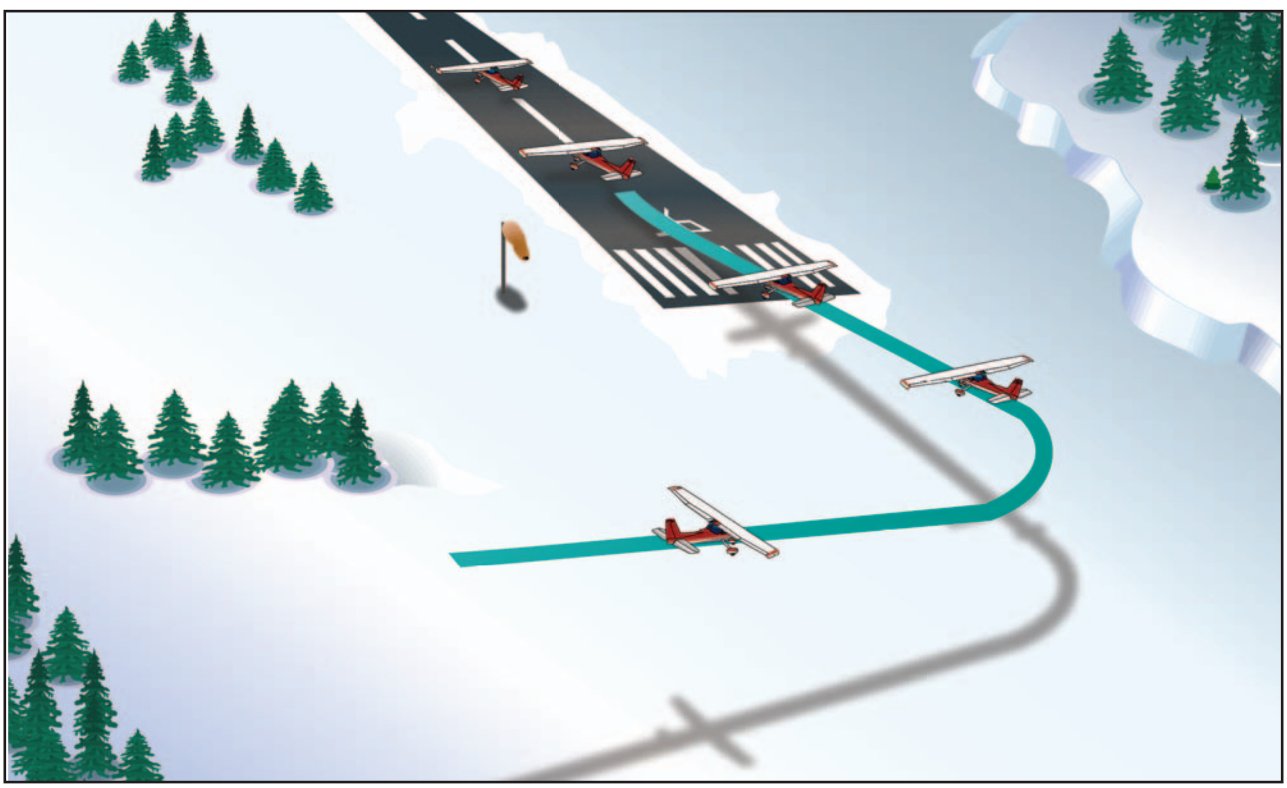

Figure 8-1. Base leg and final approach.

flaps. Normally, the landing gear should be extended and the before landing check completed prior to reaching the base leg.

After turning onto the base leg, the pilot should start the descent with reduced power and airspeed of approximately 1.4 V_{SO}. (V_{SO}—the stalling speed with power off, landing gears and flaps down.) For example, if V_{SO} is 60 knots, the speed should be 1.4 times 60, or 84 knots. Landing flaps may be partially lowered, if desired, at this time. Full flaps are not recommended until the final approach is established. Drift correction should be established and maintained to follow a ground track perpendicular to the extension of the centerline of the runway on which the landing is to be made. Since the final approach and landing will normally be made into the wind, there will be somewhat of a crosswind during the base leg. This requires that the airplane be angled sufficiently into the wind to prevent drifting farther away from the intended landing spot.

The base leg should be continued to the point where a medium to shallow-banked turn will align the airplane's path directly with the centerline of the landing runway. This descending turn should be completed at a safe altitude that will be dependent upon the height of the terrain and any obstructions along the ground track. The turn to the final approach should also be sufficiently above the airport elevation to permit a final approach long enough for the pilot to accurately estimate the resultant point of touchdown, while maintaining the proper approach airspeed. This will require careful planning as to the starting point and the radius of the turn. Normally, it is recommended that the angle of bank not exceed a medium bank because the steeper the angle of bank, the higher the airspeed at which the airplane stalls. Since the base-to-final turn is made at a relatively low altitude, it is important that a stall not occur at this point. If an extremely steep bank is needed to prevent overshooting the proper final approach path, it is advisable to discontinue the approach, go around, and plan to start the turn earlier on the next approach rather than risk a hazardous situation.

FINAL APPROACH

After the base-to-final approach turn is completed, the longitudinal axis of the airplane should be aligned with the centerline of the runway or landing surface, so that drift (if any) will be recognized immediately. On a normal approach, with no wind drift, the longitudinal axis should be kept aligned with the runway centerline throughout the approach and landing. (The proper way to correct for a crosswind will be explained under the section, Crosswind Approach and Landing. For now, only an approach and landing where the wind is straight down the runway will be discussed.)

After aligning the airplane with the runway centerline, the final flap setting should be completed and the pitch attitude adjusted as required for the desired rate of descent. Slight adjustments in pitch and power may be necessary to maintain the descent attitude and the desired approach airspeed. In the absence of the manufacturer's recommended airspeed, a speed equal to 1.3 V_{SO} should be used. If V_{SO} is 60 knots, the speed should be 78 knots. When the pitch attitude and airspeed have been stabilized, the airplane should be retrimmed to relieve the pressures being held on the controls.

The descent angle should be controlled throughout the approach so that the airplane will land in the center of the first third of the runway. The descent angle is affected by all four fundamental forces that act on an airplane (lift, drag, thrust, and weight). If all the forces are constant, the descent angle will be constant in a no-wind condition. The pilot can control these forces by adjusting the airspeed, attitude, power, and drag (flaps or forward slip). The wind also plays a prominent part in the gliding distance over the ground [Figure 8-2]; naturally, the pilot does not have control over the wind but may correct for its effect on the airplane's descent by appropriate pitch and power adjustments.

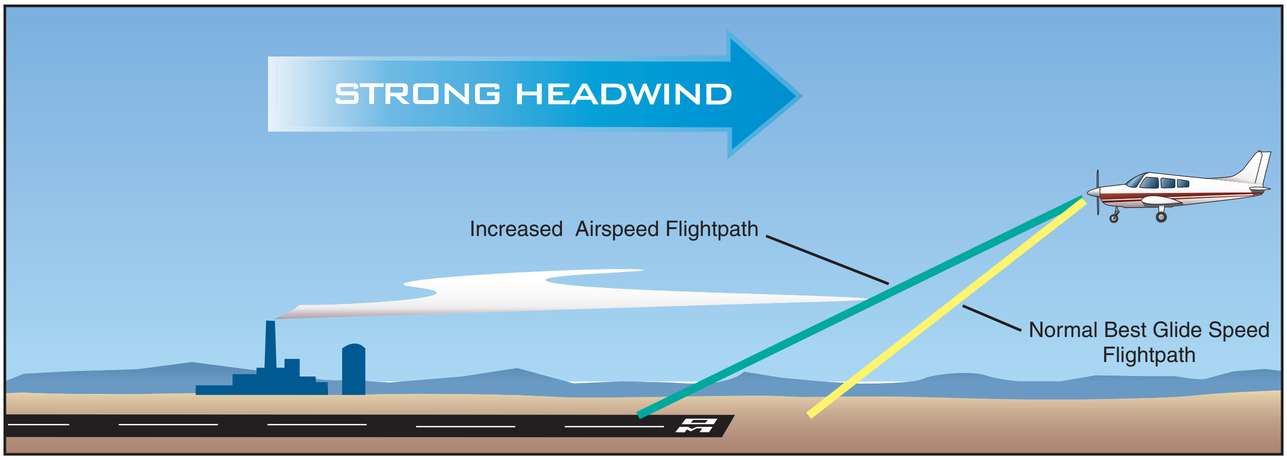

Figure 8-2. Effect of headwind on final approach.

Considering the factors that affect the descent angle on the final approach, for all practical purposes at a given pitch attitude there is only one power setting for one airspeed, one flap setting, and one wind condition. A change in any one of these variables will require an appropriate coordinated change in the other controllable variables. For example, if the pitch attitude is raised too high without an increase of power, the airplane will settle very rapidly and touch down short of the desired spot. For this reason, the pilot should never try to stretch a glide by applying back-elevator pressure alone to reach the desired landing spot. This will shorten the gliding distance if power is not added simultaneously. The proper angle of descent and airspeed should be maintained by coordinating pitch attitude changes and power changes.

The objective of a good final approach is to descend at an angle and airspeed that will permit the airplane to reach the desired touchdown point at an airspeed which will result in minimum floating just before touchdown; in essence, a semi-stalled condition. To accomplish this, it is essential that both the descent angle and the airspeed be accurately controlled. Since on a normal approach the power setting is not fixed as in a power-off approach, the power and pitch attitude should be adjusted simultaneously as necessary, to control the airspeed, and the descent angle, or to attain the desired altitudes along the approach path. By lowering the nose and reducing power to keep approach airspeed constant, a descent at a higher rate can be made to correct for being too high in the approach. This is one reason for performing approaches with partial power; if the approach is too high, merely lower the nose and reduce the power. When the approach is too low, add power and raise the nose.

USE OF FLAPS

The lift/drag factors may also be varied by the pilot to adjust the descent through the use of landing flaps. [Figures 8-3 and 8-4] Flap extension during landings provides several advantages by:

- Producing greater lift and permitting lower landing speed.
- Producing greater drag, permitting a steep descent angle without airspeed increase.
- Reducing the length of the landing roll.

Flap extension has a definite effect on the airplane's pitch behavior. The increased camber from flap deflection produces lift primarily on the rear portion of the wing. This produces a nosedown pitching moment; however, the change in tail loads from the **downwash** deflected by the flaps over the horizontal tail has a significant influence on the pitching moment. Consequently, pitch behavior depends on the design features of the particular airplane.

Flap deflection of up to 15° primarily produces lift with minimal drag. The airplane has a tendency to **balloon**

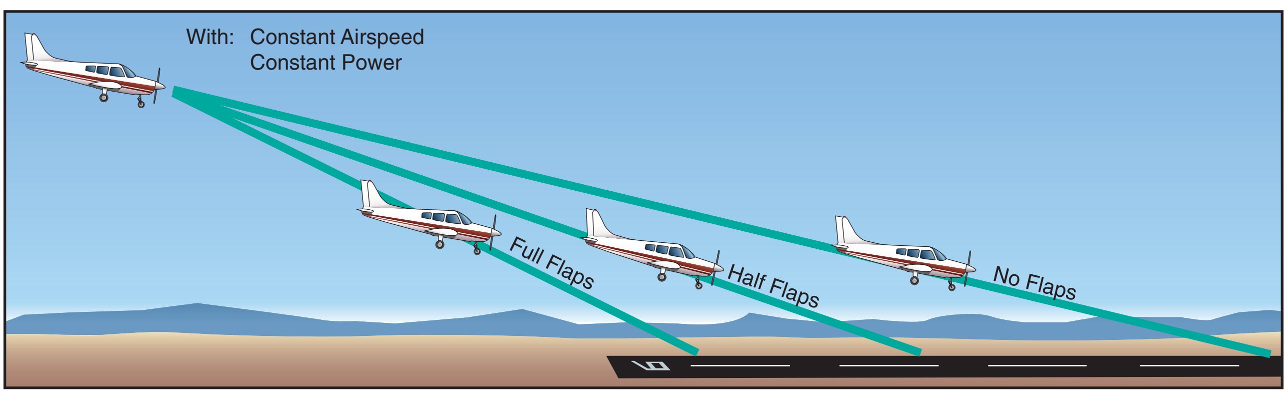

Figure 8-3. Effect of flaps on the landing point.

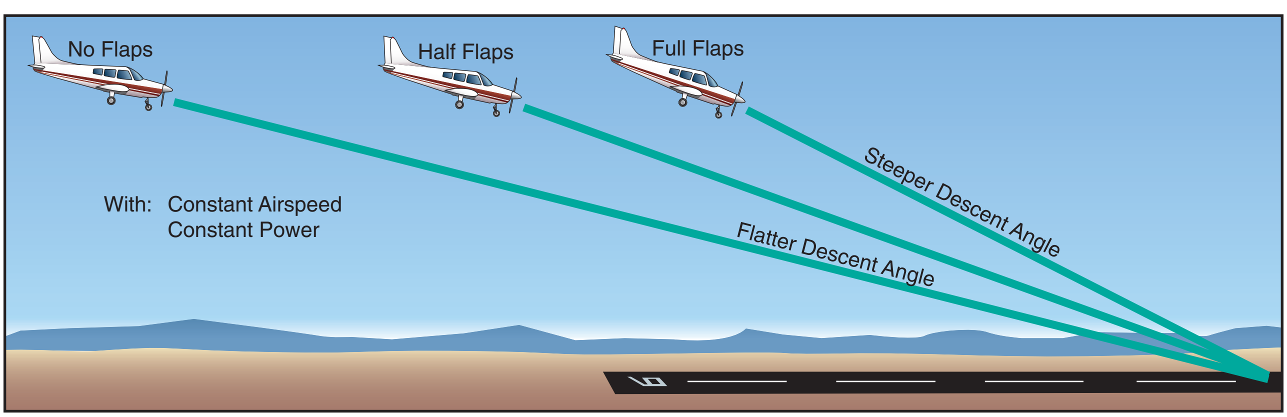

Figure 8-4. Effect of flaps on the approach angle.

up with initial flap deflection because of the lift increase. The nosedown pitching moment, however, tends to offset the balloon. Flap deflection beyond 15° produces a large increase in drag. Also, deflection beyond 15° produces a significant noseup pitching moment in high-wing airplanes because the resulting downwash increases the airflow over the horizontal tail.

The time of flap extension and the degree of deflection are related. Large flap deflections at one single point in the landing pattern produce large lift changes that require significant pitch and power changes in order to maintain airspeed and descent angle. Consequently, the deflection of flaps at certain positions in the landing pattern has definite advantages. Incremental deflection of flaps on downwind, base leg, and final approach allow smaller adjustment of pitch and power compared to extension of full flaps all at one time.

When the flaps are lowered, the airspeed will decrease unless the power is increased or the pitch attitude lowered. On final approach, therefore, the pilot must estimate where the airplane will land through discerning judgment of the descent angle. If it appears that the airplane is going to overshoot the desired landing spot, more flaps may be used if not fully extended or the power reduced further, and the pitch attitude lowered. This will result in a steeper approach. If the desired landing spot is being undershot and a shallower approach is needed, both power and pitch attitude should be increased to readjust the descent angle. Never retract the flaps to correct for undershooting since that will suddenly decrease the lift and cause the airplane to sink even more rapidly.

The airplane must be retrimmed on the final approach to compensate for the change in aerodynamic forces. With the reduced power and with a slower airspeed, the airflow produces less lift on the wings and less downward force on the horizontal stabilizer, resulting in a significant nosedown tendency. The elevator must then be trimmed more noseup.

It will be found that the roundout, touchdown, and landing roll are much easier to accomplish when they are preceded by a proper final approach with precise control of airspeed, attitude, power, and drag resulting in a stabilized descent angle.

ESTIMATING HEIGHT AND MOVEMENT

During the approach, roundout, and touchdown, vision is of prime importance. To provide a wide scope of vision and to foster good judgment of height and movement, the pilot's head should assume a natural, straight-ahead position. The pilot's visual focus should not be fixed on any one side or any one spot ahead of the airplane, but should be changing slowly from a point just over the airplane's nose to the desired touchdown zone and back again, while maintaining a deliberate awareness of distance from either side of the runway within the pilot's peripheral field of vision.

Accurate estimation of distance is, besides being a matter of practice, dependent upon how clearly objects are seen; it requires that the vision be focused properly in order that the important objects stand out as clearly as possible.

Speed blurs objects at close range. For example, most everyone has noted this in an automobile moving at high speed. Nearby objects seem to merge together in a blur, while objects farther away stand out clearly. The driver subconsciously focuses the eyes sufficiently far ahead of the automobile to see objects distinctly.

The distance at which the pilot's vision is focused should be proportionate to the speed at which the airplane is traveling over the ground. Thus, as speed is reduced during the roundout, the distance ahead of the airplane at which it is possible to focus should be brought closer accordingly.

If the pilot attempts to focus on a reference that is too close or looks directly down, the reference will become blurred, [Figure 8-5] and the reaction will be either too abrupt or too late. In this case, the pilot's tendency will be to overcontrol, round out high, and make full-stall, drop-in landings. When the pilot focuses too far ahead, accuracy in judging the closeness of the ground is lost and the consequent reaction will be too slow since there will not appear to be a necessity for action. This will result in the airplane flying into the ground nose first. The change of visual focus from a long distance to a short distance requires a definite time interval and even though the time is brief, the airplane's speed during this interval is such that the airplane travels an appreciable distance, both forward and downward toward the ground.

Figure 8-5. Focusing too close blurs vision.

If the focus is changed gradually, being brought progressively closer as speed is reduced, the time interval

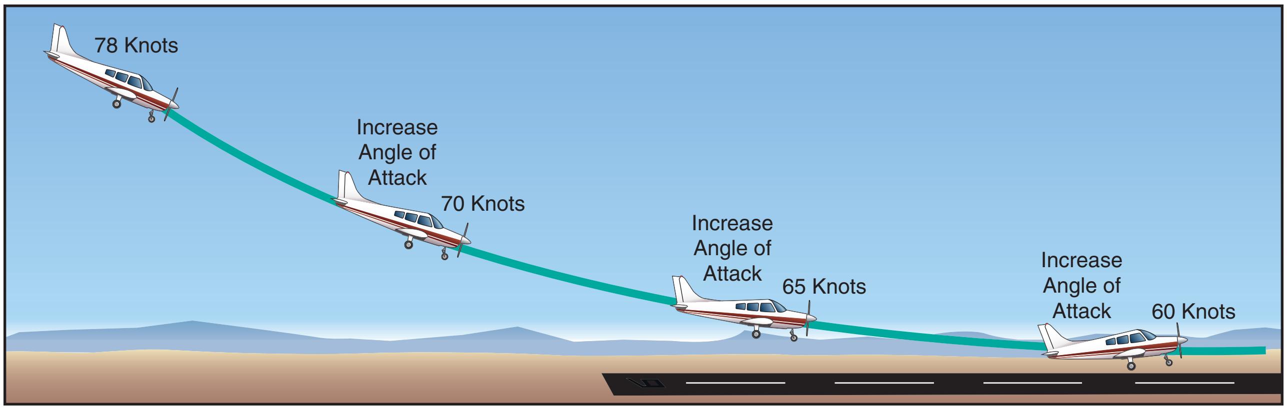

Figure 8-6. Changing angle of attack during roundout.

and the pilot's reaction will be reduced, and the whole landing process smoothed out.

ROUNDOUT (FLARE)

The roundout is a slow, smooth transition from a normal approach attitude to a landing attitude, gradually rounding out the flightpath to one that is parallel with, and within a very few inches above, the runway. When the airplane, in a normal descent, approaches within what appears to be 10 to 20 feet above the ground, the roundout or flare should be started, and once started should be a continuous process until the airplane touches down on the ground.

As the airplane reaches a height above the ground where a timely change can be made into the proper landing attitude, back-elevator pressure should be gradually applied to slowly increase the pitch attitude and angle of attack. [Figure 8-6] This will cause the airplane's nose to gradually rise toward the desired landing attitude. The angle of attack should be increased at a rate that will allow the airplane to continue settling slowly as forward speed decreases.

When the angle of attack is increased, the lift is momentarily increased, which decreases the rate of descent. Since power normally is reduced to idle during the roundout, the airspeed will also gradually decrease. This will cause lift to decrease again, and it must be controlled by raising the nose and further increasing the angle of attack. During the roundout, the airspeed is being decreased to touchdown speed while the lift is being controlled so the airplane will settle gently onto the landing surface. The roundout should be executed at a rate that the proper landing attitude and the proper touchdown airspeed are attained simultaneously just as the wheels contact the landing surface.

The rate at which the roundout is executed depends on the airplane's height above the ground, the rate of descent, and the pitch attitude. A roundout started excessively high must be executed more slowly than one from a lower height to allow the airplane to descend to the ground while the proper landing attitude is being established. The rate of rounding out must also be proportionate to the rate of closure with the ground. When the airplane appears to be descending very slowly, the increase in pitch attitude must be made at a correspondingly slow rate.

Visual cues are important in flaring at the proper altitude and maintaining the wheels a few inches above the runway until eventual touchdown. Flare cues are primarily dependent on the angle at which the pilot's central vision intersects the ground (or runway) ahead and slightly to the side. Proper depth perception is a factor in a successful flare, but the visual cues used most are those related to changes in runway or terrain perspective and to changes in the size of familiar objects near the landing area such as fences, bushes, trees, hangars, and even sod or runway texture. The pilot should direct central vision at a shallow downward angle of from 10° to 15° toward the runway as the roundout/flare is initiated. [Figure 8-7] Maintaining the same viewing angle causes the point

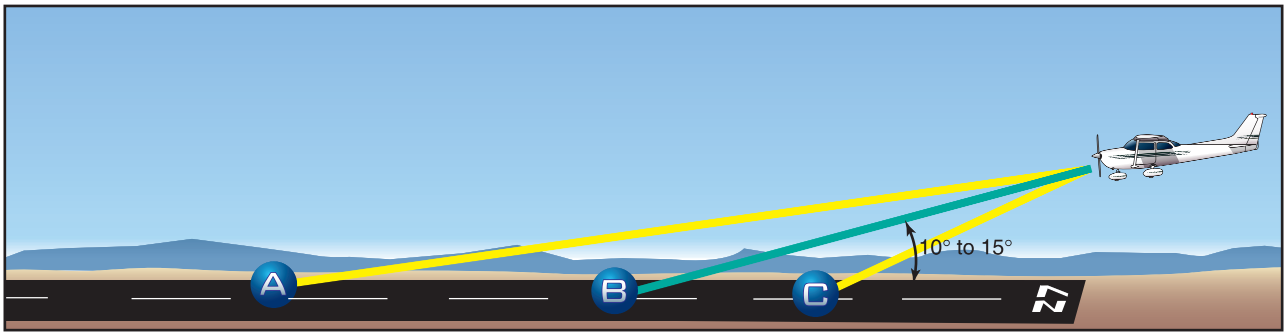

Figure 8-7. To obtain necessary visual cues, the pilot should look toward the runway at a shallow angle.

of visual interception with the runway to move progressively rearward toward the pilot as the airplane loses altitude. This is an important visual cue in assessing the *rate* of altitude loss. Conversely, forward movement of the visual interception point will indicate an increase in altitude, and would mean that the pitch angle was increased too rapidly, resulting in an over flare. Location of the visual interception point in conjunction with assessment of flow velocity of nearby off-runway terrain, as well as the similarity of appearance of height above the runway ahead of the airplane (in comparison to the way it looked when the airplane was taxied prior to takeoff) is also used to judge when the wheels are just a few inches above the runway.

The pitch attitude of the airplane in a full-flap approach is considerably lower than in a no-flap approach. To attain the proper landing attitude before touching down, the nose must travel through a greater pitch change when flaps are fully extended. Since the roundout is usually started at approximately the same height above the ground regardless of the degree of flaps used, the pitch attitude must be increased at a faster rate when full flaps are used; however, the roundout should still be executed at a rate proportionate to the airplane's downward motion.

Once the actual process of rounding out is started, the elevator control should not be pushed forward. If too much back-elevator pressure has been exerted, this pressure should be either slightly relaxed or held constant, depending on the degree of the error. In some cases, it may be necessary to advance the throttle slightly to prevent an excessive rate of sink, or a stall, all of which would result in a hard, drop-in type landing.

It is recommended that the student pilot form the habit of keeping one hand on the throttle throughout the approach and landing, should a sudden and unexpected hazardous situation require an immediate application of power.

TOUCHDOWN

The touchdown is the gentle settling of the airplane onto the landing surface. The roundout and touchdown should be made with the engine idling, and the airplane at minimum controllable airspeed, so that the airplane will touch down on the main gear at approximately stalling speed. As the airplane settles, the proper landing attitude is attained by application of whatever back-elevator pressure is necessary.

Some pilots may try to force or fly the airplane onto the ground without establishing the proper landing attitude. The airplane should never be flown on the runway with excessive speed. It is paradoxical that the way to make an ideal landing is to try to hold the airplane's wheels a few inches off the ground as long as possible with the elevators. In most cases, when the wheels are within 2 or 3 feet off the ground, the airplane will still be settling too fast for a gentle touchdown; therefore, this descent must be retarded by further back-elevator pressure. Since the airplane is already close to its stalling speed and is settling, this added back-elevator pressure will only slow up the settling instead of stopping it. At the same time, it will result in the airplane touching the ground in the proper landing attitude, and the main wheels touching down first so that little or no weight is on the nosewheel. [Figure 8-8]

After the main wheels make initial contact with the ground, back-elevator pressure should be held to maintain a positive angle of attack for aerodynamic braking, and to hold the nosewheel off the ground until the airplane decelerates. As the airplane's momentum decreases, back-elevator pressure may be gradually relaxed to allow the nosewheel to gently settle onto the runway. This will permit steering with the nosewheel. At the same time, it will cause a low angle of attack and negative lift on the wings to prevent floating or skipping, and will allow the full weight of the airplane to rest on the wheels for better braking action.

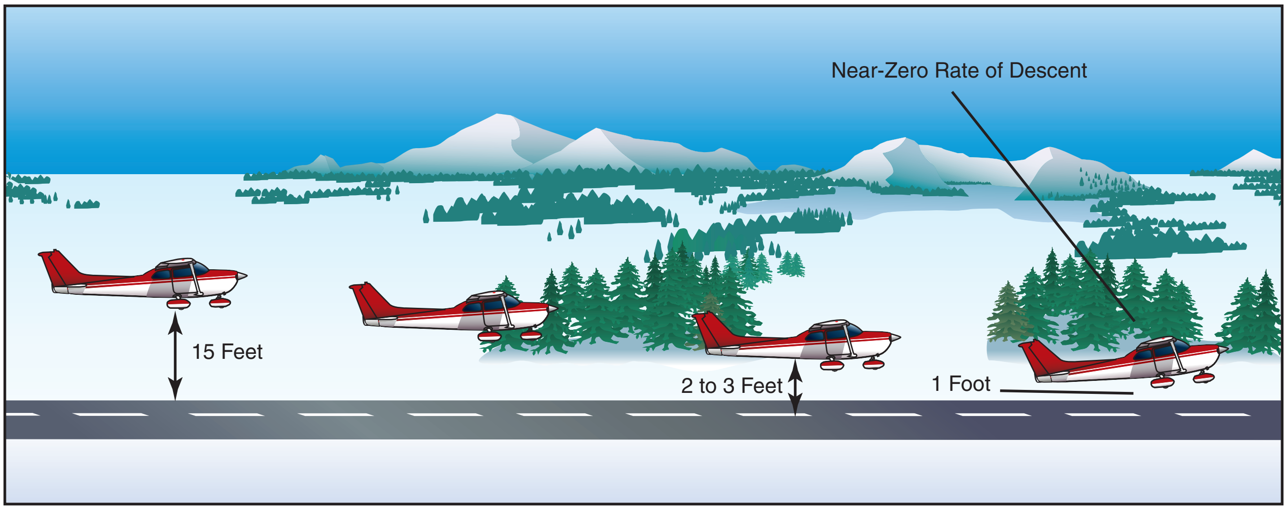

Figure 8-8. A well executed roundout results in attaining the proper landing attitude.

It is extremely important that the touchdown occur with the airplane's longitudinal axis exactly parallel to the direction in which the airplane is moving along the runway. Failure to accomplish this imposes severe side loads on the landing gear. To avoid these side stresses, the pilot should not allow the airplane to touch down while turned into the wind or drifting.

AFTER-LANDING ROLL

The landing process must never be considered complete until the airplane decelerates to the normal taxi speed during the landing roll or has been brought to a complete stop when clear of the landing area. Many accidents have occurred as a result of pilots abandoning their vigilance and positive control after getting the airplane on the ground.

The pilot must be alert for directional control difficulties immediately upon and after touchdown due to the ground friction on the wheels. The friction creates a pivot point on which a moment arm can act. Loss of directional control may lead to an aggravated, uncontrolled, tight turn on the ground, or a **ground loop**. The combination of centrifugal force acting on the center of gravity (CG) and ground friction of the main wheels resisting it during the ground loop may cause the airplane to tip or lean enough for the outside wingtip to contact the ground. This may even impose a sideward force, which could collapse the landing gear.

The rudder serves the same purpose on the ground as it does in the air—it controls the yawing of the airplane. The effectiveness of the rudder is dependent on the airflow, which depends on the speed of the airplane. As the speed decreases and the nosewheel has been lowered to the ground, the steerable nose provides more positive directional control.

The brakes of an airplane serve the same primary purpose as the brakes of an automobile—to reduce speed on the ground. In airplanes, they may also be used as an aid in directional control when more positive control is required than could be obtained with rudder or nosewheel steering alone.

To use brakes, on an airplane equipped with toe brakes, the pilot should slide the toes or feet up from the rudder pedals to the brake pedals. If rudder pressure is being held at the time braking action is needed, that pressure should not be released as the feet or toes are being slid up to the brake pedals, because control may be lost before brakes can be applied.

Putting maximum weight on the wheels after touchdown is an important factor in obtaining optimum braking performance. During the early part of rollout, some lift may continue to be generated by the wing. After touchdown, the nosewheel should be lowered to the runway to maintain directional control. During deceleration, the nose may be pitched down by braking and the weight transferred to the nosewheel from the main wheels. This does not aid in braking action, so back pressure should be applied to the controls without lifting the nosewheel off the runway. This will enable the pilot to maintain directional control while keeping weight on the main wheels.

Careful application of the brakes can be initiated after the nosewheel is on the ground and directional control is established. Maximum brake effectiveness is just short of the point where skidding occurs. If the brakes are applied so hard that skidding takes place, braking becomes ineffective. Skidding can be stopped by releasing the brake pressure. Also, braking effectiveness is not enhanced by alternately applying and reapplying brake pressure. The brakes should be applied firmly and smoothly as necessary.

During the ground roll, the airplane's direction of movement can be changed by carefully applying pressure on one brake or uneven pressures on each brake in the desired direction. Caution must be exercised when applying brakes to avoid overcontrolling.

The ailerons serve the same purpose on the ground as they do in the air—they change the lift and drag components of the wings. During the after-landing roll, they should be used to keep the wings level in much the same way they were used in flight. If a wing starts to rise, aileron control should be applied toward that wing to lower it. The amount required will depend on speed because as the forward speed of the airplane decreases, the ailerons will become less effective. Procedures for using ailerons in crosswind conditions are explained further in this chapter, in the Crosswind Approach and Landing section.

After the airplane is on the ground, back-elevator pressure may be gradually relaxed to place normal weight on the nosewheel to aid in better steering. If available runway permits, the speed of the airplane should be allowed to dissipate in a normal manner. Once the airplane has slowed sufficiently and has turned on to the taxiway and stopped, the pilot should retract the flaps and clean up the airplane. Many accidents have occurred as a result of the pilot unintentionally operating the landing gear control and retracting the gear instead of the flap control when the airplane was still rolling. The habit of positively identifying both of these controls, before actuating them, should be formed from the very beginning of flight training and continued in all future flying activities.

STABILIZED APPROACH CONCEPT

A *stabilized approach* is one in which the pilot establishes and maintains a constant angle glidepath towards a predetermined point on the landing runway. It is based on the pilot's judgment of certain visual clues, and depends on the maintenance of a constant final descent airspeed and configuration.

An airplane descending on final approach at a constant rate and airspeed will be traveling in a straight line toward a spot on the ground ahead. This spot will not be the spot on which the airplane will touch down, because some float will inevitably occur during the roundout (flare). [Figure 8-9] Neither will it be the spot toward which the airplane's nose is pointed, because the airplane is flying at a fairly high angle of attack, and the component of lift exerted parallel to the Earth's surface by the wings tends to carry the airplane forward horizontally.

horizon appears to increase (aiming point moving down away from the horizon), then the true aiming point, and subsequent touchdown point, is farther down the runway. If the distance between the perceived aiming point and the horizon decreases (aiming point moving up toward the horizon), the true aiming point is closer than perceived.

When the airplane is established on final approach, the shape of the runway image also presents clues as to what must be done to maintain a stabilized approach to a safe landing.

A runway, obviously, is normally shaped in the form of an elongated rectangle. When viewed from the air during the approach, the phenomenon known as

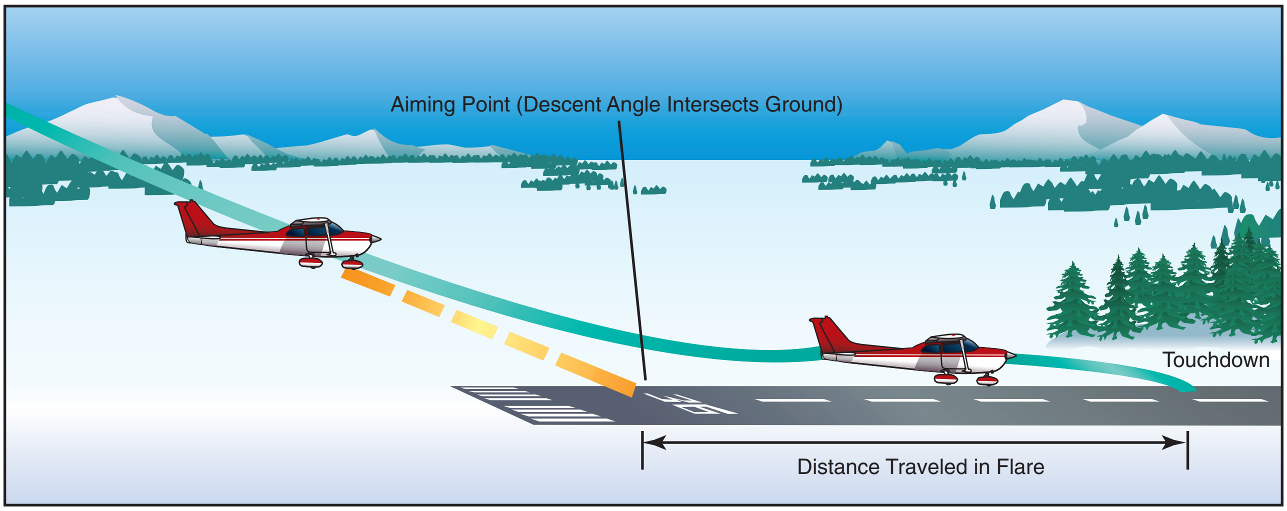

Figure 8-9. Stabilized approach.

The point toward which the airplane is progressing is termed the "aiming point." [Figure 8-9] It is the point on the ground at which, if the airplane maintains a constant glidepath, and was *not* flared for landing, it would strike the ground. To a pilot moving straight ahead toward an object, it appears to be stationary. It does not "move." This is how the aiming point can be distinguished—*it does not move*. However, objects in front of and beyond the aiming point do appear to move as the distance is closed, and they appear to move in opposite directions. During instruction in landings, one of the most important skills a student pilot must acquire is how to use visual cues to accurately determine the true aiming point from any distance out on final approach. From this, the pilot will not only be able to determine if the glidepath will result in an undershoot or overshoot, but, taking into account float during roundout, the pilot will be able to predict the touchdown point to within a very few feet.

For a constant angle glidepath, the distance between the horizon and the aiming point will remain constant. If a final approach descent has been established but the distance between the perceived aiming point and the

perspective causes the runway to assume the shape of a trapezoid with the far end looking narrower than the approach end, and the edge lines converging ahead. If the airplane continues down the glidepath *at a constant angle* (stabilized), the image the pilot sees will still be trapezoidal but of proportionately larger dimensions. In other words, *during a stabilized approach the runway shape does not change.* [Figure 8-10]

If the approach becomes shallower, however, the runway will appear to shorten and become wider. Conversely, if the approach is steepened, the runway will appear to become longer and narrower. [Figure 8-11]

The objective of a stabilized approach is to select an appropriate touchdown point on the runway, and adjust the glidepath so that the true aiming point and the desired touchdown point basically coincide. Immediately after rolling out on final approach, the pilot should adjust the pitch attitude and power so that the airplane is descending directly toward the aiming point at the appropriate airspeed. The airplane should

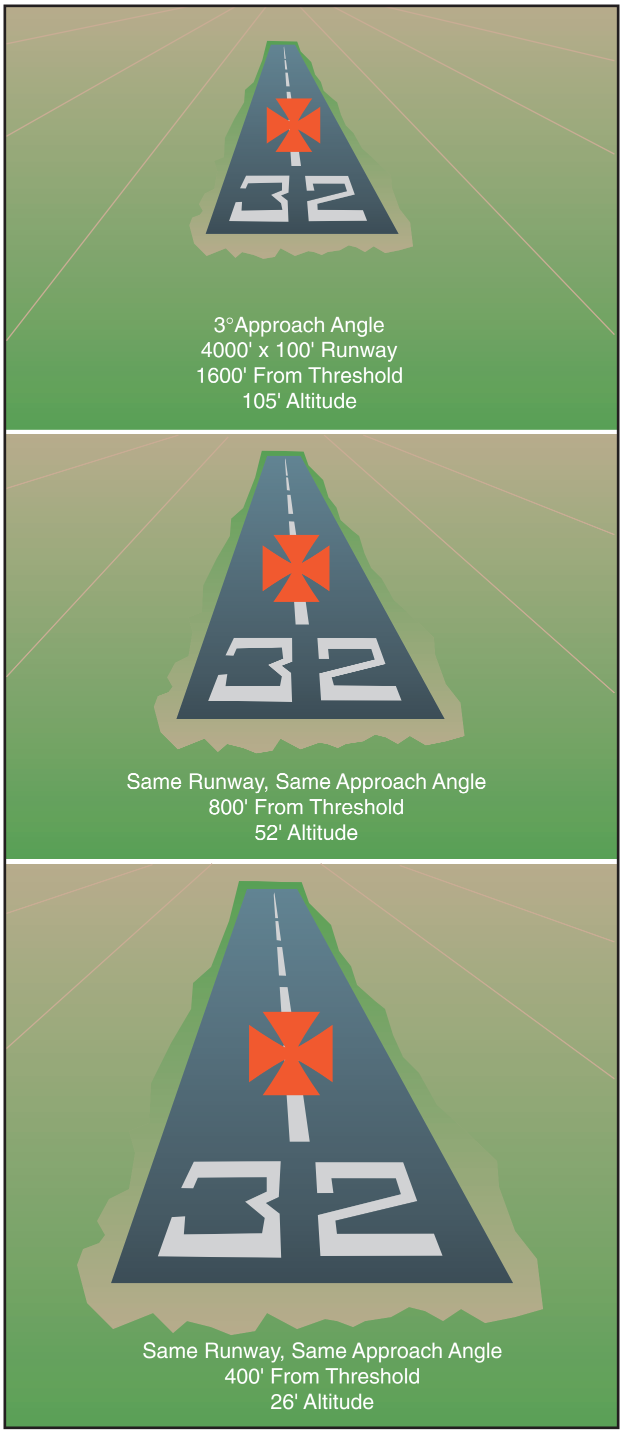

Figure 8-10. Runway shape during stabilized approach.

be in the landing configuration, and trimmed for "hands off" flight. With the approach set up in this manner, the pilot will be free to devote full attention toward outside references. The pilot should not stare at any one place, but rather scan from one point to another, such as from the aiming point to the horizon, to the trees and bushes along the runway, to an area well short of the runway, and back to the aiming point. In this way, the pilot will be more apt to perceive a deviation from the desired glidepath, and whether or not the airplane is proceeding directly toward the aiming point.

Figure 8-11. Change in runway shape if approach becomes narrow or steep.

If the pilot perceives any indication that the aiming point on the runway is not where desired, an adjustment must be made to the glidepath. This in turn will move the aiming point. For instance, if the pilot perceives that the aiming point is short of the desired touchdown point and will result in an undershoot, an increase in pitch attitude and engine power is warranted. A constant airspeed must be maintained. The pitch and power change, therefore, must be made smoothly and simultaneously. This will result in a shallowing of the glidepath with the resultant aiming point moving towards the desired touchdown point. Conversely, if the pilot perceives that the aiming point is farther down the runway than the desired touchdown point and will result in an overshoot, the glidepath should be steepened by a simultaneous decrease in pitch attitude and power. Once again, the airspeed must be held constant. **It is essential that deviations from the desired glidepath be detected early, so that only slight and infrequent adjustments to glidepath are required.**