When Seeing is *NOT* Believing

Some tips on keeping out of trouble when visual clues try to mislead you

by BARRY SCHIFF / AOPA 110803

■■ The world of flight can be strangely deceptive, offering many misleading clues that should not be believed even though they can be seen.

Take the classic example of the VFR pilot flying above an inclined cloud layer. Because he is not disciplined in the skills of instrument flying, the pilot perceives the sloped cloud layer as the natural horizon. Influenced by this illusion, he tends to fly askew unless able to rationalize the deceptive visual reference with the less conspicuous, contradictory display of the attitude instruments.

Many pilots have difficulty flying over desolate terrain on a moonless, VFR night. Even though there are no ground or celestial references, they attempt to fly visually in conditions clearly requiring instrument flying techniques.

The situation is complicated by the introduction of a single light on the horizon, a target toward which a pilot can aim his craft. If the pilot stares at this beckoning beacon for any period of time, it may soon appear to move from side to side in wide, irregular arcs—a phenomenon known as autokinetic motion, or "stare vision."

In the absence of other outside references, a pilot's senses often interpret this apparent movement of light as a change in aircraft heading or attitude. As a result, the pilot—without realizing it—maneuvers the aircraft so as to keep the light positioned in his windshield. In the meantime, his senses provide the erroneous sensation that the aircraft is on an even keel. The instruments contradict this sensory illusion, but a confused pilot may choose to ignore them. A sufficiently bewildered pilot could encounter vertigo and possible loss of aircraft control.

Autokinetic motion can be duplicated by sitting in an otherwise dark room and staring at a pinpoint of light. After a short while, the light can be observed drifting in various directions, a most perplexing phenomenon.

The U.S. Air Force has blamed numerous night VFR accidents on autokinetic motion and teaches its pilots to never stare at a single light source in an otherwise dark flight environment and to frequently glance at the more trustworthy message spelled out on the instrument panel.

In 1952, Capt. Prosper Cocquyt of Sabena Belgian World Airlines prepared an award-winning paper describing another dangerous illusion with respect to night flying and a light on the ground. Unfortunately, this profound information never reached the general-aviation audience even though this sensory "deception" has been, in part, the probable cause of many night accidents.

The problem deals with VFR night flying at a relatively low altitude (such as when approaching or departing an airport), when the natural horizon is not visible.

Figure 1a shows a wings-level aircraft flying abeam a light on the ground. The pilot senses that he is at a safe altitude because the light appears below the aircraft (as it should). But consider Figure 1b, a situation where the pilot inadvertently allows the aircraft to bank to the left. (Remember, the horizon is not visible.) By glancing at the light, which is sighted by looking parallel to the wing, the pilot perceives that the aircraft and the light are at the same altitude—ground level. This produces the erroneous sensation of an urgent need to climb. The illusion received when a pilot has inadvertently banked toward a light is considered a "safe-side" illusion because altitude is perceived to be less than actual and the pilot, by climbing, will err on the safe side.

The dangerous illusion is shown in Figure 1c, a situation where the aircraft is inadvertently allowed to bank away from the light. The pilot has no sensation of being too low because he thinks that he is looking down at the light when, in fact, he is not. Unless the pilot sees the silent warning of the artificial horizon, he might be the victim of a fatal shock.

Inadvertent excursions in pitch also can have serious consequences. Figure 2a shows an aircraft approaching a light

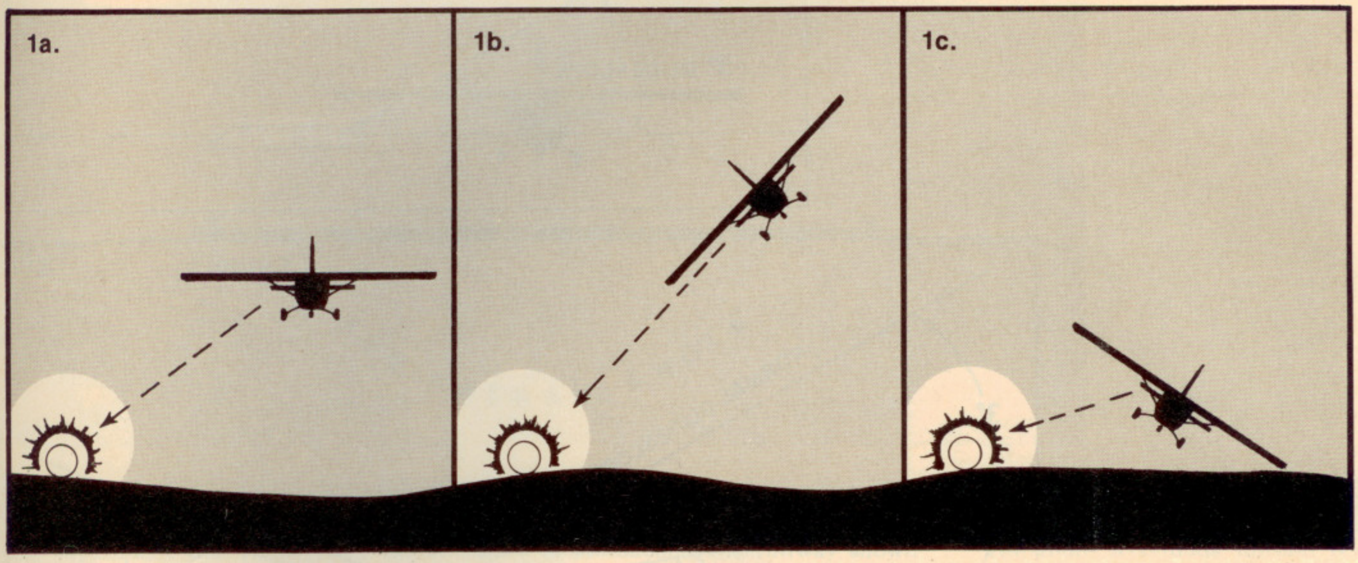


Figure 1

(or group of lights) on the ground. Since the aircraft is maintaining a constant altitude, the pilot must look down at an angle to see the approaching lights. If this angle is sufficiently large, the pilot senses that he is at a safe altitude. But suppose that he inadvertently allows the nose to rise slightly while at a dangerously low altitude as shown in Figure 2b. The pilot senses being at a safe altitude because he appears to be looking down at a large angle when, in reality, he is looking primarily forward.

Such an illusion is most likely to occur during a nose-high departure at night toward gently rising terrain especially when there are no visible landmarks between the aircraft and the light(s) toward which the aircraft is heading. A pilot can be easily deceived into believing that he will clear an obstacle.

A night approach toward an airport can create an equally dangerous illusion if there are no visible landmarks between the aircraft and the airport. Under these conditions, a pilot can be totally unaware that he is being lured into the ground.

The departure problem can be prevented by climbing in the traffic pattern until a safe altitude is reached. Arrival difficulties are best resolved by avoiding straight-in approaches when the approach corridor is dark or by utilizing a steep descent path toward the airport.

An additional illusion is often encountered during a straight-in approach at night when the visibility is unlimited, a condition frequently found in the desert and mountain areas of the West. Approach and runway lights appear brighter than usual at such times and cause a pilot to believe that he is closer to the airport than he really is. The result is often a premature descent toward intervening obstacles.

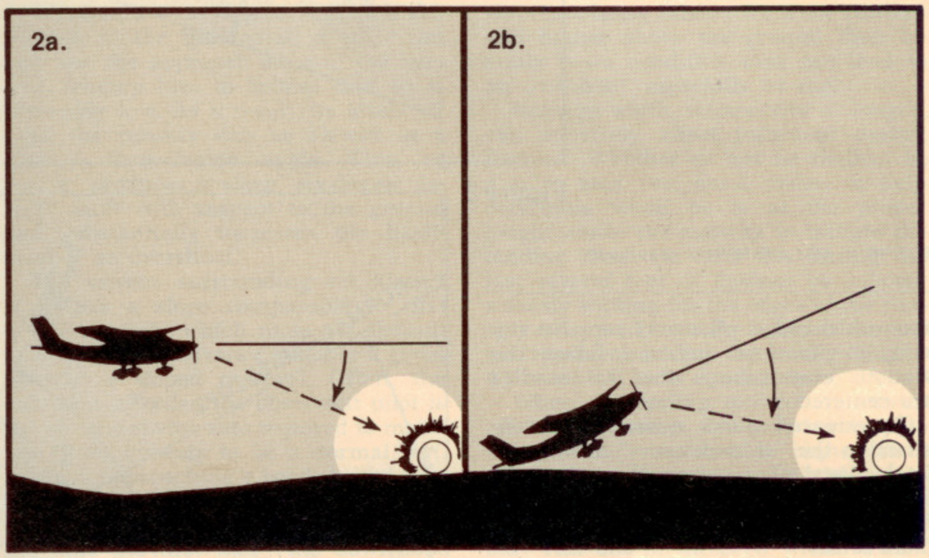


Figure 2

For this reason, experienced mountain pilots often delay a descent until safely within the confines of the traffic pattern. They use another interesting technique, which although quite logical when you think about it, is something that most pilots are unaware of.

When descending toward a distant city, for example, keep a sharp eye on the lights at that edge of the city closest to the aircraft. Should any of these lights disappear, then something (such as a ridge) has risen to block the view and dictates an urgent need to arrest the descent and recapture altitude until the lights are once again visible. As long as these lights remain in sight, the aircraft is above all enroute obstacles.

Restricted visibility also can be deceptive because of the dimming effect it has on airport lights. When approaching an airport on a hazy night, for example, a pilot unknowingly interprets his altitude as being higher than actual. This phenomenon results in the common tendency of a pilot (when first sighting the runway during an ILS approach) to reduce power and drop below the glideslope, an extremely hazardous reaction.

During daylight hours, the effect is similar because visibility restrictions dilute shadows normally used as an aid to depth perception.

Moisture on the windshield can produce unpredictable illusory effects because of the irregular refraction of light caused by the droplets. Depending on the moisture pattern and the shape of

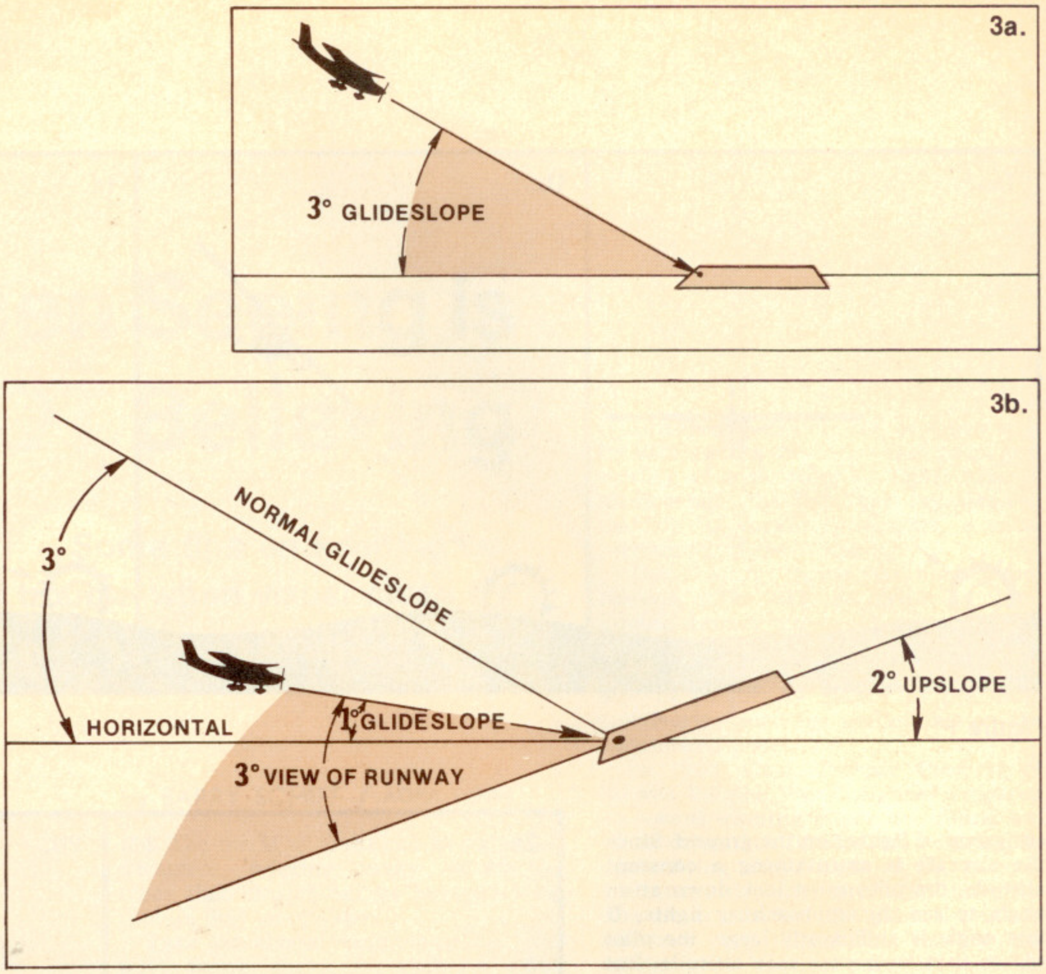
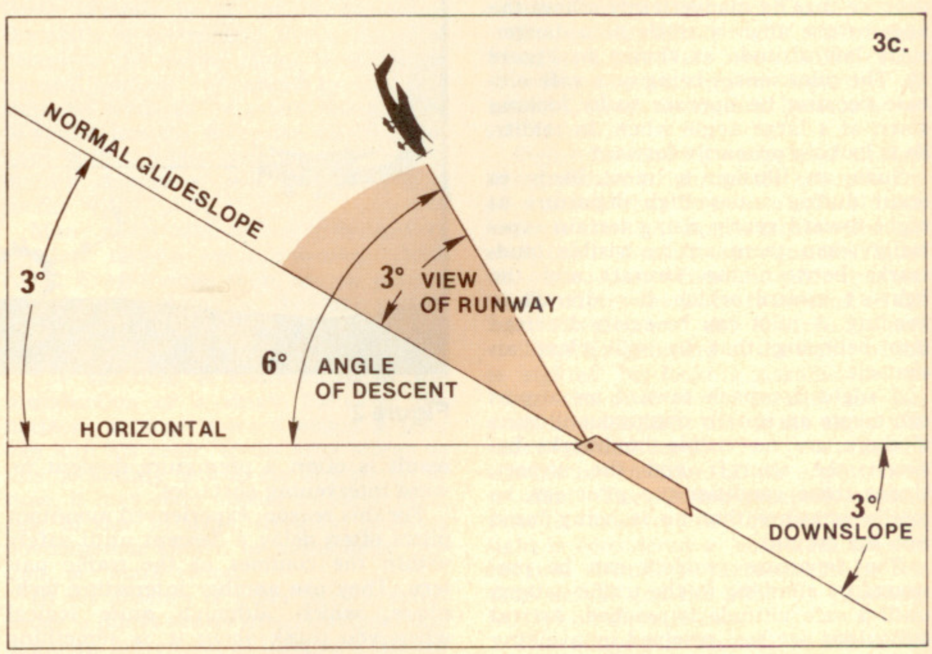


Figure 3



the windshield, a pilot may perceive significant glideslope and/or localizer deviations even though the ILS needles are centered.

Experienced pilots never completely abandon the "cross-pointers" during the final, visual phase of an ILS approach. Instead, they monitor the needles to confirm that outside clues are not leading them astray.

Variations in runway and approach lighting intensity can also be misleading. When these lights are set to maximum intensity, the airport appears closer than it is. Conversely, when the light are dim, the airport appears farther away.

During the preparation of this article, I flew with a friend who was asked to approach an airport at night while maintaining 3,000 feet agl. He was instructed not to descend until intercepting what seemed to be a normal, three-degree, visual-approach slot. The ILS needles were hidden from his view and, unknown to him, I had prearranged with the tower controller to vary the runway and approach lighting intensity during the experiment.

As we began the long, straight-in approach, the airport lights were set to minimum intensity and, predictably, the subject pilot was considerably above the glideslope before initiating descent; he sensed being farther out than he really was. I clicked the mike button twice, which signaled the controller to gradually increase the lights to maximum brilliance. As the lights "came up," I noticed a gradual increase in sink rate and power reduction until, finally, we were literally diving toward the airport.

Although well above the glideslope at the beginning of descent, we were now uncomfortably below it. This became more apparent as we neared the approach lights, causing the confused pilot to add considerable power and back pressure to prevent the impending undershoot.

Although a pilot is not likely to experience such gross variations in lighting intensity during any given approach,

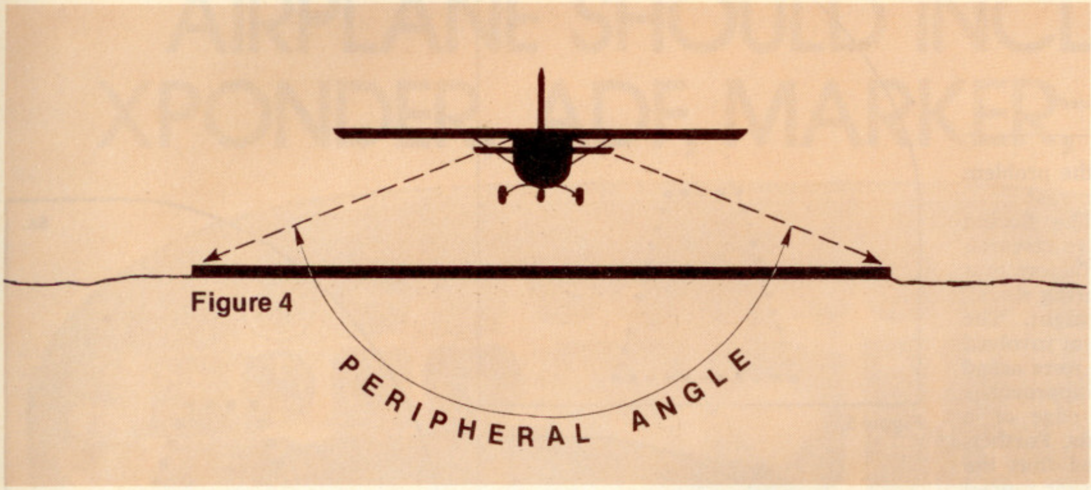


Figure 4

this experiment did verify (and exaggerate) the illusory effects that can be expected when airport lights are unusually dim or bright.

Although most illusions occur at night, daylight operations also offer some fascinating deceptions.

Figure 3a shows an aircraft in a normal, three-degree, visual descent toward a level runway. The pilot can maintain this "three-degree slot" quite accurately because he has spent his flying career practicing approaches that "feel" comfortable. He approaches a runway so that the visual glideslope "seems" neither too shallow nor too steep.

A visual illusion develops when approaching a runway with a pronounced upslope (Figure 3b). If a pilot establishes a three-degree approach slot relative to the horiziontal, while approaching a runway with a two-degree upslope, for example, he would feel that he is descending too steeply. This is because he would be aware of descending at a five-degree angle with respect to the runway. As a result, the pilot automatically compensates by "dropping down" until the runway "looks right." In other words, he settles onto a three-degree glidepath with respect to the runway, as he always does. Unfortunately, this results in a dangerously low, flat approach.

One popular southern California resort airport, Catalina, is reputedly hazardous because the first half of the runway has considerable upslope. Unsuspecting pilots are affected by the illusion and approach this airport at dangerously shallow descent paths. Numerous aircraft have made impressions (literally) on the bluff at the approach end of Catalina's Runway 22, causing the FAA to install a set of VASI lights recently. When followed religiously, Catalina's VASI prevents the previously common undershoot accident, but pilots must resist the urge to fly below the red-and-white glidepath, which does appear steep but, in fact, is not.

The downslope runway (Figure 3c) leads to overshoots. The runway shown in the diagram has an admittedly steep (three-degree) downslope, but illustrates the illusion associated with shallower downslopes.

When in a three-degree approach slot relative to the horizontal, a pilot can only see the approach edge of the runway, leading him to believe that he is extremely low. As a result, he levels off until the runway can be viewed at a normal, three-degree angle. This, of course, produces a steep, six-degree descent path with respect to the ground and substantially increases the likelihood of an overshoot.

The terrain surrounding an airport often has a slope comparable to that of the runway, which makes it difficult to determine in advance whether a given runway is sloped or level. Often, the only clue afforded the observant pilot is the abnormal sink rate required to maintain what appears to be a normal slot.

When approaching a bowl-shaped runway with a pronounced dip in the middle, the proper procedure would be to use only the first half (the downslope portion) of the runway to establish a visual glidepath. By maintaining what then appears to be a somewhat flat approach, you'll be close to the proper slot.

Conversely, if the runway is convex (a hump in the middle), refer only to the first, *uphill* portion of the runway and establish what appears to be a slightly steep approach path.

Runway geometry also can be deceiving. Without realizing it, a pilot usually assesses the runway before him by comparing it with the runway to which he is most accustomed. Assume that a pilot is conditioned to landing on a 4,500- by 150-foot runway (which has a length-to-width ratio of 30:1). From above and afar, a longer runway with the same proportions (6,000 by 200, for example) has an identical appearance. But because the runway is larger, the pilot is led to believe that he is closer and lower than he really is.

The more hazardous illusion occurs when approaching a shorter runway with those same, familiar proportions (2,250 by 75, for example). While on final to this smaller runway, the pilot perceives being farther from the runway and higher above the ground than he really is—a condition that can lead to an overshoot, especially at night.

Runway width, irrespective of length, can adversely affect judgment during flareout. Whether or not he realizes it, a pilot uses peripheral vision to help determine when he is at the proper height above the runway to initiate the landing flare. He does this during the last several feet of descent by subconsciously waiting for the edges of the runway to spread laterally beneath the aircraft until reaching the angle (Figure 4) to which he is conditioned.

When descending toward an unusually wide runway, this peripheral angle forms while considerably higher than usual above the ground. By yielding to the subconscious suggestion that he initiate the flare at this time, a pilot may run out of airspeed while several feet in the air. Conversely, when descending toward a narrow runway, the lateral spread of the runway edges may not be sufficient for the peripheral clue to form and can result in the failure of a pilot to flare in time to avoid a hard landing.

The problems posed by wide and narrow runways are particularly acute at night when it is more difficult to judge height above the ground. This is because of the lack of contrast between the runway and the surrounding terrain. All is in blackness, a condition that decreases depth perception. Similar loss of depth perception occurs during daylight hours when there is little or no contrast between the runway and the adjacent terrain, such as when the entire airport is snow or water covered, when landing on open areas of dirt or grass; and when approaching hard-surface runways surrounded by similarly colored sand. Visibility restrictions aggravate the problem by further reducing color contrast.

During the late 1960s, The Boeing Co. instituted a comprehensive research program to determine those factors that adversely influence a pilot during visual, straight-in approaches at night. The practical aspect of his program involved 12 senior jet instructors who were asked to execute several simulated approaches to an airport at the near edge of a sprawling matrix of city lights. Furthermore, each pilot was advised that the city (not the airport) had a pronounced upslope. Not only did most of the test pilots fly considerably below the normal glideslope, but many flew their simulators below the elevation of the airport.

One major problem of a straight-in approach at night is the frequent lack of a natural horizon. But by practicing the following technique, a pilot can learn to create an imaginary one.

Figure 5a displays the runway as seen from the cockpit on a night when the horizon is not visible. Since the parallel rows of runway lights, when extended, intersect at the horizon (Figure 5b), the pilot can project an imaginary horizon on his windshield.

This is a particularly useful technique when hilltop lights beyond the airport (Figure 5c) elevate the apparent horizon to a confusing height. When such a false horizon is used instead of the real one, a pilot is led to believe he is on a normal glideslope when he is actually far below.

When a pilot passes over the approach lights at night, the runway lights occupy a large portion of the windshield area (Figure 6a). But when sliding down the electronic banister to very poor visibilities (4,000 feet RVR or less), a pilot breaks out of the overcast and sees only the lights in the touchdown zone (Figure 6b). These appear in the lower portion of the windscreen and create the illusion of being too high. It is a natural tendency under these conditions for a pilot to tuck below the glideslope in a subconscious effort to fill more of the windshield area with lights, as is usually the case when visibility is good. To call this dangerous is an understatement—it is the direct cause of numerous undershoot accidents following ILS approaches.

If all the runway lights are not visible when breaking out of an overcast, attempt to mentally extend those that are visible to create the image of a full-length runway (Figure 6c). I have practiced this technique when shooting Category I and II approaches in a Boeing 727, and it works surprisingly well.

The National Transportation Safety Board is responsible for determining the probable causes of all fatal aviation accidents. In many cases, the epitaph at the end of a report often states, with obvious simplicity, that the pilot failed to maintain adequate altitude or airspeed.

What is not so obvious are the reasons why a pilot might have been misled in the first place. Often, he has been the victim of one or a combination of sensory illusions, which prove that seeing should not always be believing. □

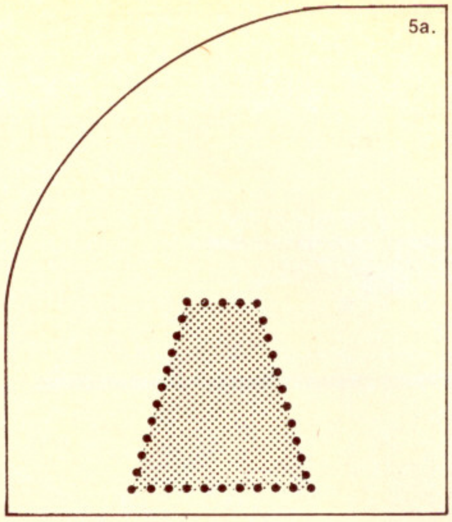
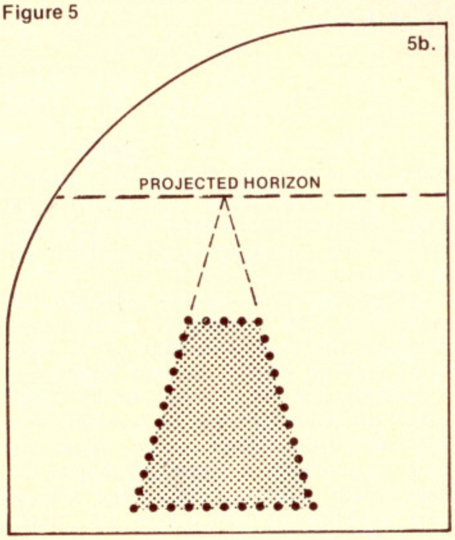


Figure 5



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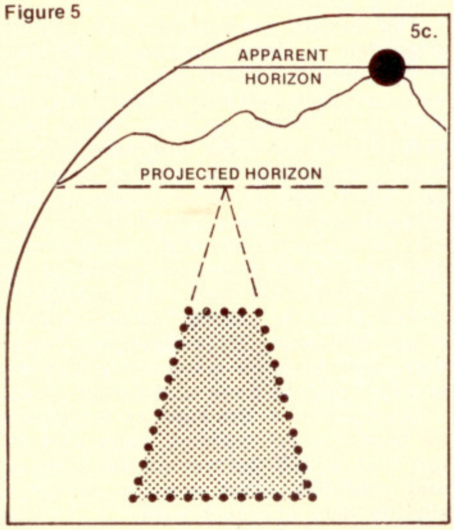

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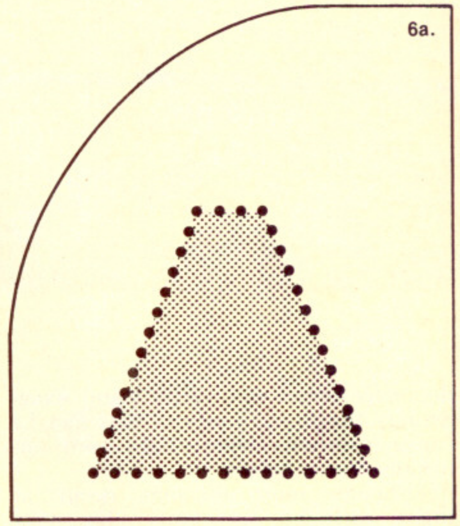

Figure 6

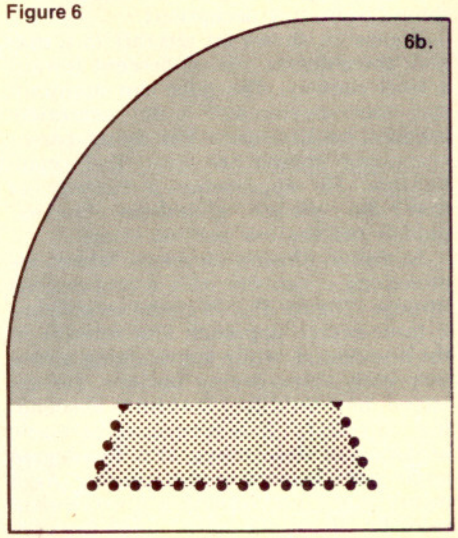

Figure 6

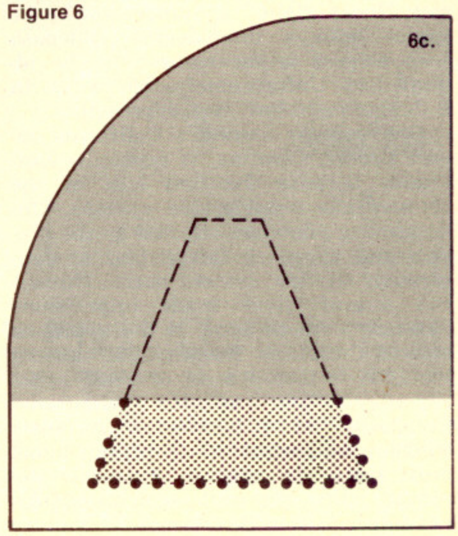

Figure 6