Pilot Alert: Wake Turbulence

FAA provides The PILOT with updated recommendations for coping with wingtip vortices. New Advisory Circular will contain same suggested operational procedures

■■ "Some of today's jet aircraft, and particularly the new (civil and military) jumbo jets, generate vortices with roll velocities exceeding the roll control capability of some aircraft. Further, turbulence generated within the vortices can damage aircraft components and equipment, if encountered at close range."

The preceding is FAA's latest assessment of the wake turbulence hazards created by big jets. The general assessment was made shortly after completion of two comprehensive field-training programs that revealed and documented the fact that the dangers previously had been underestimated [July PILOT, page 27; April PILOT, page 54].

At press time, engineers and scientists from FAA and the National Aeronautics and Space Administration (NASA) were still engaged in sorting out, categorizing, and correlating a multitude of new details that were learned about wake turbulence from the testing programs. Final results are expected to be compiled in a technical report for careful perusal by the scientific and engineering community.

Sharply aware of the potential hazards posed to general aviation operators by the unwelcome phenomena, The PILOT sought out and readily received cooperation and assistance from FAA's Flight Standards Service officials in updating recommendations for pilots to cope with the problem. The cooperation and assistance was particularly worthy of note due to past and continuing cases of minimal assistance provided by some branches of FAA, most notably the FAA's Air Traffic Service, in meeting the desires and requirements of general aviation users and their representatives.

All of the following recommendations, as well as basic drawings for the accompanying sketches to assist pilots in better understanding those recommendations, were supplied by FAA. Most, if not all, of the following information and similar sketches will be incorporated in a new FAA Advisory Circular (AC) on wake turbulence.

"The FAA's air traffic control system is applying separation standards designed to preclude wake encounters," said FAA. "However, in most VFR situations, the pilot sets up his own separation from other aircraft. In doing so, he also controls his potential exposure to the trailing vortices of other aircraft. To assure safety during VFR operations, the pilot must learn to envision the location of the vortex wake generated by a large aircraft and adjust his flight path accordingly."

Properly noting that the vortex problem is a "two-way street," involving both aircraft that might encounter the swirling masses and those generating the vortices, FAA's Flight Standards Service stated: "It is equally important that pilots of medium and large aircraft plan their flight paths to minimize vortex exposure to other aircraft."

Figures 1, 2 and 3 accompanying this article graphically show: (1) formation of wingtip vortices; (2) how they induce roll on an encountering aircraft; and (3) the finding that the wingspan of the encountering aircraft is a prime factor in its ability to withstand such an encounter.

As described in Figure 1, vortices are caused by the differential in pressure over the wing surfaces. The airflow under the wing bends outward toward the tip of the wing in an effort to equalize the pressure.

"The resulting circulation and the downwash effect of the airflow over the wing causes the air leaving each trailing edge to form a vortex sheet that rolls itself up into a swirling spiral of air aft of the wingtips," FAA said. "After the roll up is completed, the wake consists of two counter-rotating vortices. On modern swept-wing aircraft, the roll-up process is well under way even before the flow leaves the wingtips."

Strength of the vortex is governed primarily by the weight, speed, and shape of the wing of the generating aircraft.

"The vortex characteristics of any

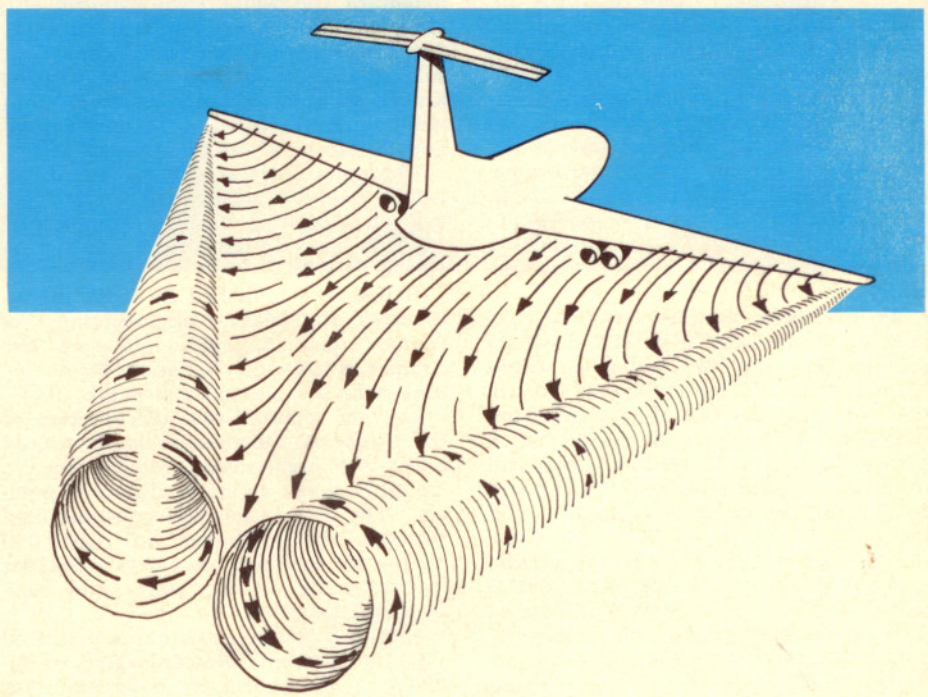


FIGURE 1. The rolling-up process.

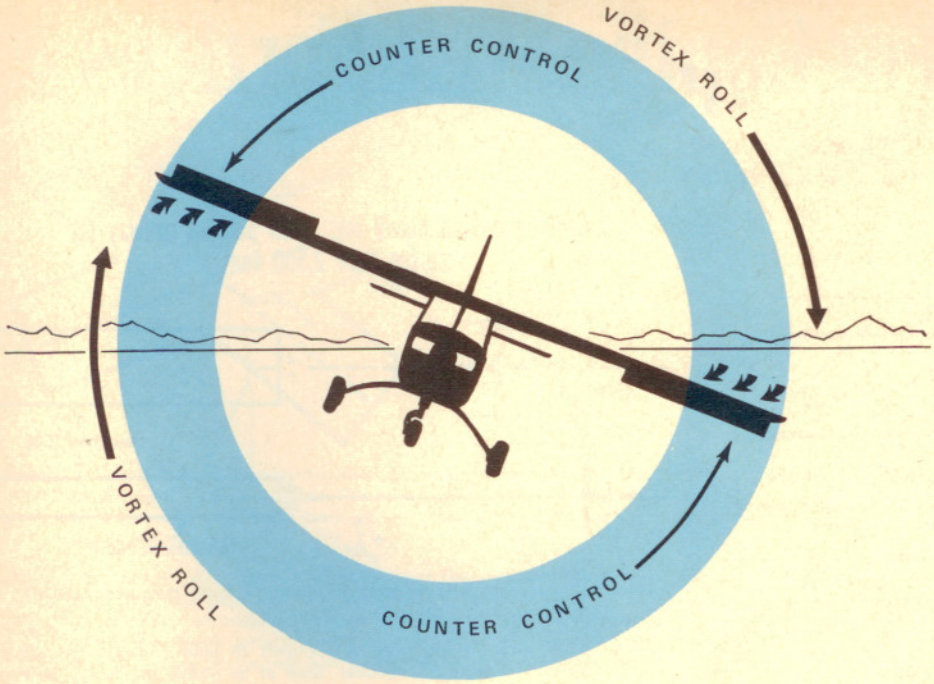


FIGURE 2. Induced roll.

given aircraft can also be changed by extension of flaps, or other wing-configuring devices, as well as by change in speed."

The greatest vortex strength occurs when the generating aircraft is heavy, clean, and slow, FAA added. "During a recent test, vortex tangential velocities were recorded at 150 feet per second, or about 90 knots," the agency reported."

Regarding Figure 2 and the induced roll of a smaller aircraft encountering the wake of a larger aircraft, FAA stated: "A serious wake encounter could result in structural damage. However, the primary hazard is loss of control because of induced roll. Aircraft intentionally flown directly up the core of a vortex during flight tests tended to roll with that vortex. The capability of counteracting this roll depends on the span and counter-control responsiveness of the encountering aircraft."

The relative span of the aircraft running into the vortices is the significant factor in its ability to withstand the turbulence. "Where the wingspan and ailerons of larger aircraft extend beyond the vortex, counter control is usually effective, and the induced roll is minimal.

"If the ailerons of a short-span aircraft were wholly within the vortex, its counter-control effectiveness would be substantially reduced. If the vortex strength were to exceed the counter-control capability of the encountering aircraft, the induced roll could not be stopped," FAA said. Although not necessary, agency officials added, "The wake of the large jets requires the respect of all pilots. Pilots of short-span aircraft must be especially alert to vortex situations even though their aircraft is one of the high-performance types."

As mentioned earlier, the vortex circulation is outward, upward, and around the wingtip, when viewed from either ahead or behind the generating aircraft. "Tests with heavy aircraft have shown that the diameter of the vortex core ranges from 25 to 50 feet, but the field of influence is larger. The vortices stay close together (about ¾ of the wingspan) until dissipation. In view of this, if persistent vortex turbulence is encountered, a slight lateral change in flight path will usually avoid it."

A number of additional sketches accompany this article, depicting the recommended operational procedures to follow in avoiding wake turbulence.

In general, FAA emphasized that pilots should avoid encounters below and behind the generating aircraft, "especially at low altitudes where even a momentary wake encounter could be hazardous." Officials added, however, that "a wake encounter is not necessarily hazardous. It may be only two bumps, one for each vortex, as the wake is crossed. It can be one or more jolts, with varying severity, depending upon the direction of the encounter, distance from the generating aircraft, and point of vortex encounter. The probability of buffeting and induced roll increases when the encountering aircraft's heading is generally aligned with the vortex trail.

"Pilots should be particularly alert to calm wind conditions and situations, where the vortices remain in the touchdown area, drift downwind to a parallel runway, sink into the takeoff or landing path of a crossing runway, sink into the traffic patterns for other airports, sink into the flight path of VFR flights operating at the hemispheric altitude 500 feet below."

Air traffic controllers reportedly have been instructed to "provide VFR aircraft with whom they are in communication, and which, in the tower's opinion, may be adversely affected by potential wake turbulence from a heavy jet, the position, altitude and direction of flight of the heavy jet." This information is to be followed by the controller's stating, "Caution—wake turbulence."

"Thereafter," stated FAA officials, "the VFR pilot is expected to adjust his operations and flight path as necessary to preclude serious wake encounters."

In what amounts to a summation of FAA's current feelings over responsibility toward wake turbulence hazards, the agency said: "Government and industry groups are making concerted efforts to minimize or eliminate the hazards of trailing vortices. However, the flight disciplines necessary to assure vortex avoidance during VFR operations must be exercised by the pilot.

"Vortex visualization and avoidance is equal in importance to traffic avoidance." □

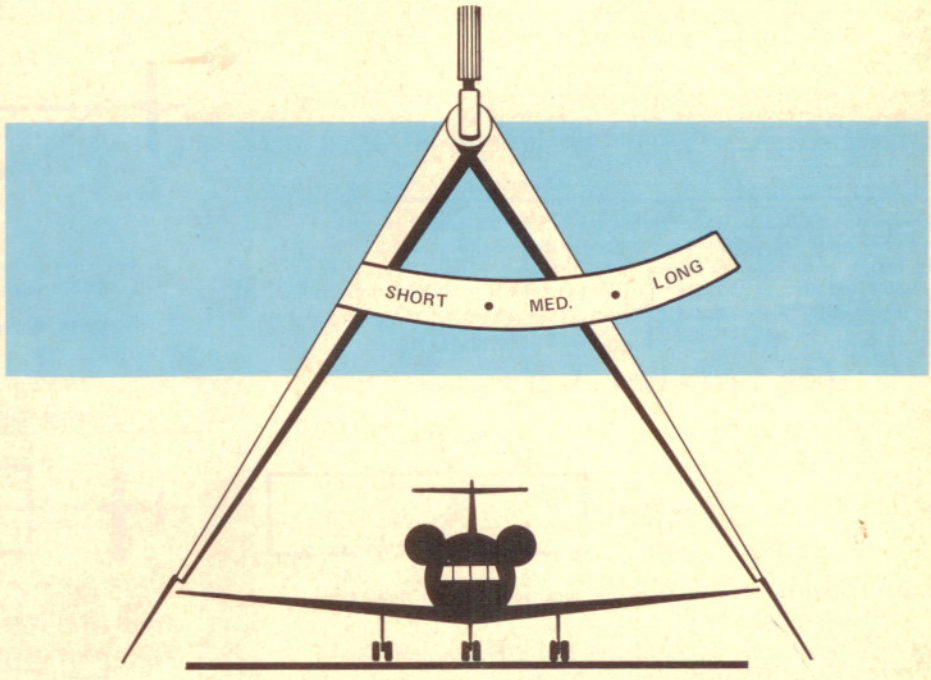
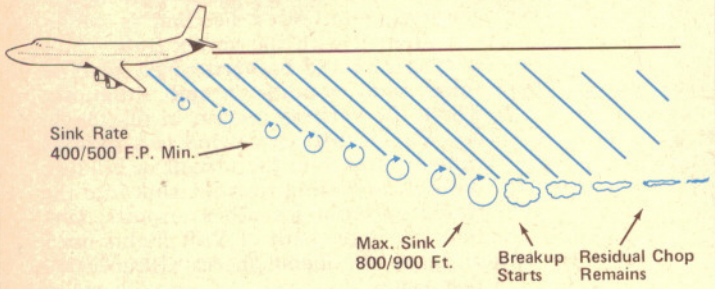


FIGURE 3. Relative Span = ability to withstand turbulence.

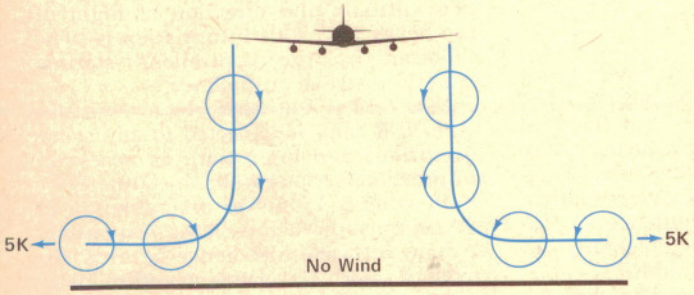
FAA Advice For Coping With Vortices

Vortex sink characteristics



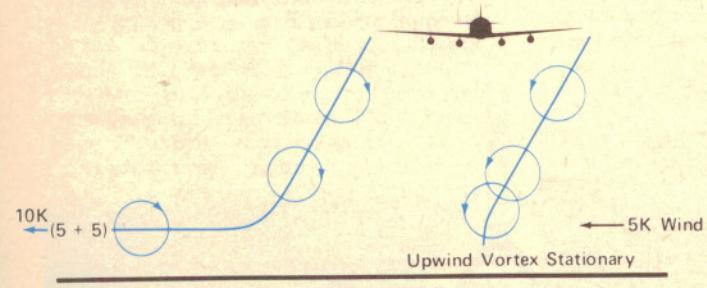
Pilots should fly at or above the heavy jet's flight path, altering course as necessary to avoid the area behind and below generating aircraft.

Vortex movement in ground effect—no wind



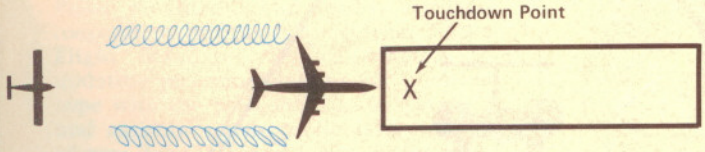
When vortices sink into ground effect, they tend to move laterally outward over the ground at a speed of about five knots.

Vortex movement in ground effect with crosswind



A crosswind component will decrease the lateral movement of the upwind vortex and increase the movement of the downwind vortex. This may result in the upwind vortex remaining in the touchdown zone, or hasten the drift of the downwind vortex toward a parallel runway.

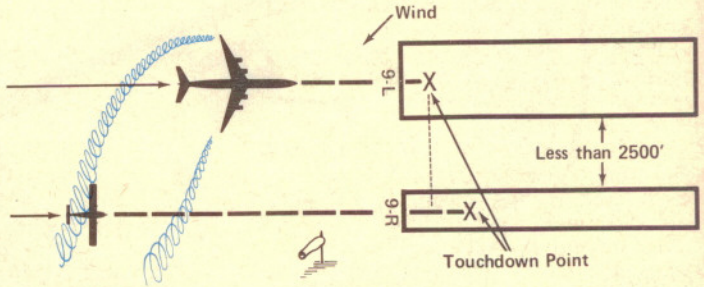
Landing behind a heavy jet—same runway



Tower: "Number two to land, following Lockheed C-5A on final. Caution, wake turbulence."

Pilot: Stay at or above the heavy jet's final approach flight path—note his touchdown point—land beyond it.

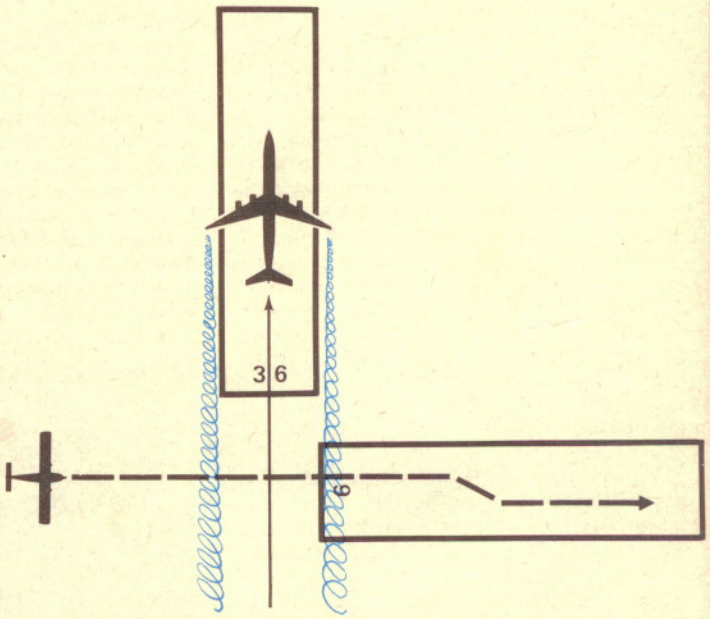
Landing behind heavy jet, when parallel runway is closer than 2,500 feet



Tower: "Cleared to land Runway 9R. Caution, wake turbulence, B-747 on final, 9L."

Pilot: Note wind for possible vortex drift to your runway—request upwind runway if practical. Stay at or above the heavy jet's final approach flight path—note his touchdown point—land beyond a point abeam his touchdown point.

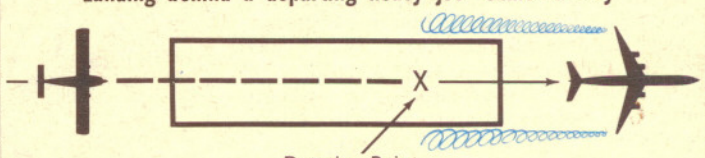
Landing behind a heavy jet—crossing runway



Tower: "Cleared to land Runway 9. Caution, wake turbulence. Boeing 747 crossing threshold, landing Runway 36."

Pilot: Cross above the heavy jet's flight path.

Landing behind a departing heavy jet—same runway



Tower: "Cleared to land. Caution, wake turbulence—C-141 departing."

Pilot: Note heavy jet's rotation point—land well prior to rotation point.

Landing behind a departing heavy jet—crossing runways

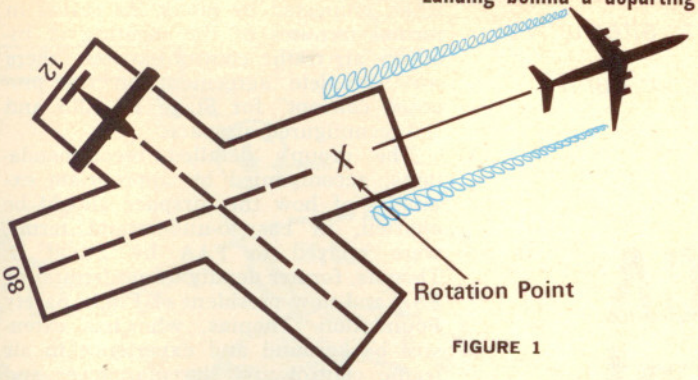


FIGURE 1

Tower: "Cleared to land Runway 12. Caution, wake turbulence—C-141 departing Runway 8." (Note: The tower will withhold clearance to land for a prescribed time period, when an in-flight crossing of paths is evident.)

Pilot: Note heavy jet's rotation point. If past the intersection, continue the approach and land prior to the intersection (Figure 1). If heavy jet rotates prior to the intersection, avoid flight below the heavy jet's flight path. Abandon the approach unless a landing is assured well before reaching the intersection (Figure 2).

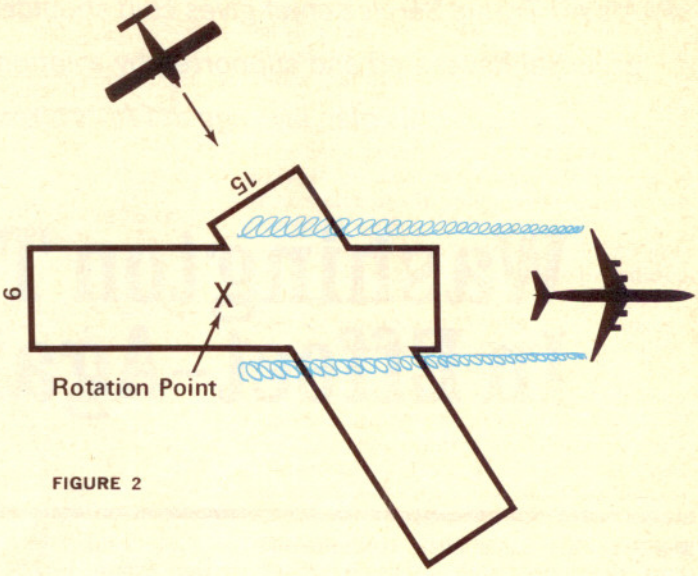


FIGURE 2

Departing behind a heavy jet

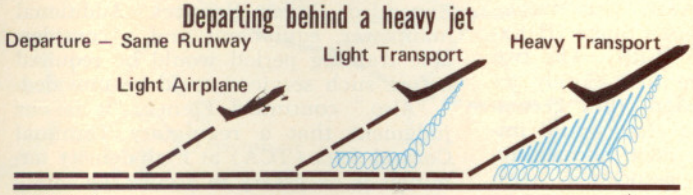


FIGURE A

FIGURE B

Crossing Departure Courses

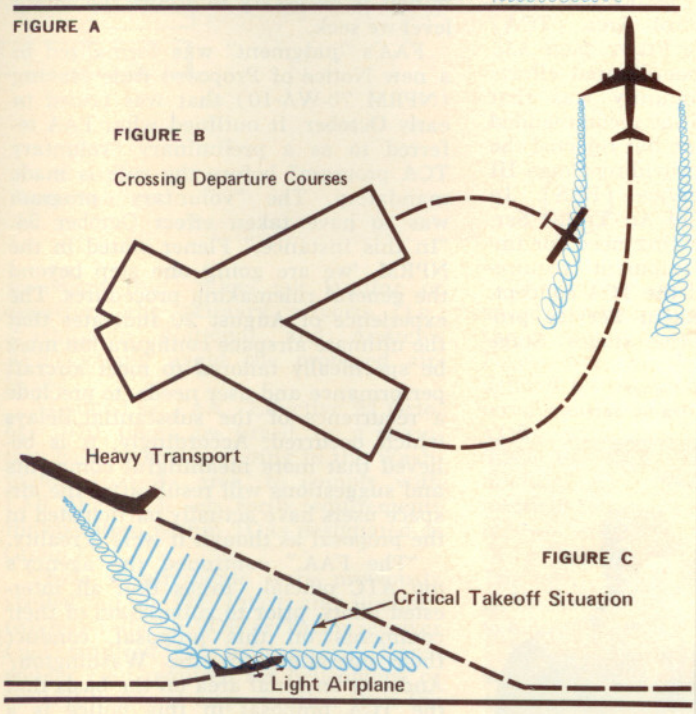
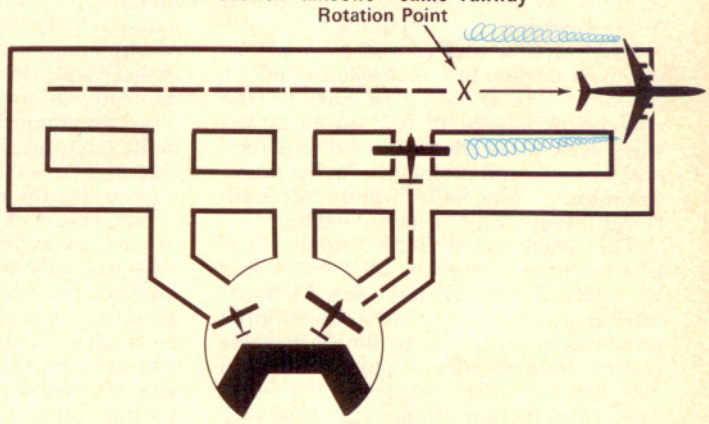


FIGURE C

Tower: ATC tower will withhold clearance for a prescribed time period [expected to be two to three minutes—Ed.] for takeoffs on the same runway, a parallel runway separated by less than 2,500 feet, and any other situation where an in-flight crossing of courses is evident.

Pilot: Note heavy jet's rotation point and rotate prior to that point; continue climb above heavy jet's climb path until turning clear of his wake (Figure A). Avoid subsequent headings that would cross below and behind a heavy jet (Figure B). Be alert for any takeoff situation that could lead to a vortex encounter (Figure C).

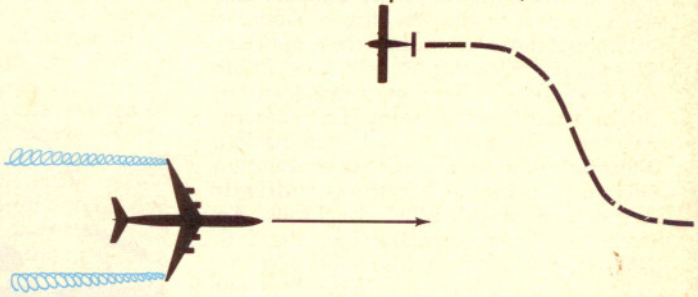
Intersection takeoffs—same runway



Tower: Towers will withhold intersection takeoff clearance for a prescribed time period behind a large turbojet aircraft on the same runway.

Pilot: Be alert to adjacent heavy jet operations, particularly upwind of your runway. If intersection takeoff clearance is received, avoid subsequent heading which will cross below a heavy jet's path.

En route VFR (altitude plus 500 feet)



Tower: No clearance involved.

Pilot: Avoid flight below and behind a heavy jet's path. If a heavy jet is observed above you on same track (same or opposite direction), adjust your position laterally, preferably upwind.