In order to obviate some of the problems of a deficiency of airspeed at takeoff, usual result can be an excess of airspeed at takeoff. The principal effect of an *excess takeoff airspeed* is the greater takeoff distance which results. The general effect is that each 1 percent excess takeoff velocity incurs approximately 2 percent additional takeoff distance. Thus, excess speed must be compared with the additional runway required to produce the higher speed. In addition, the aircraft tires may be subject to critical loads when the airplane is at very high rolling speeds and speeds in excess of a basically high takeoff speed may produce damage or failure of the tires.

As with the conditions of landing, excess velocity or deficiency of velocity at takeoff is undesirable. The proper takeoff speeds and angle of attack must be utilized to assure satisfactory takeoff performance.

GUSTS AND WIND SHEAR

The variation of wind velocity and direction throughout the atmosphere is important because of its effect on the aerodynamic forces and moments on an airplane. As the airplane traverses this variation of wind velocity and direction during flight, the changes in airflow direction and velocity create changes in the aerodynamic forces and moments and produce a response of the airplane. The variation of airflow velocity along a given direction exists with shear parallel to the flow direction. Hence, the velocity gradients are often referred to as the wind "shear."

The effect of the *vertical gust* has important effects on the airplane at high speed because of the possibility of damaging flight loads. The mechanism of vertical gust is illustrated in figure 6.5 where the vertical gust velocity is added vectorially to the flight velocity to produce some resultant velocity. The principal effect of the vertical gust is to produce a change in airplane angle of attack, e.g., a positive (up) gust causes an increase in angle of attack while a negative (down) gust causes a decrease in angle of attack. Of course, a change in angle of attack will effect a change in lift and, if some critical combination of high gust intensity and high flight speed is encountered, the change in lift may be large enough to cause structural damage.

At low flight speeds during approach, landing, and takeoff, the effect of the vertical gust is due to the same mechanism of the change in angle of attack. However, at these low flight speeds, the problem is one of possible incipient stalling and sinking rather than overstress. When the airplane is at high angle of attack, a further increase in angle of attack due to a gust may exceed the critical angle of attack and cause an incipient stalling of the airplane. Also, a decrease in angle of attack due to a gust will cause a loss of lift and allow the airplane to sink. For this reason, any deficiency of airspeed will be quite critical when operating in gusty conditions.

The effect of the *horizontal gust* differs from the effect of the vertical gust in that the immediate effect is a change of airspeed rather than a change in angle of attack. In this sense, the horizontal gust is of little consequence in the major airplane airloads and strength limitations. Of greater significance is the response of the airplane to horizontal gusts and wind shear when operating at low flight speeds. The possible conditions in which an airplane may encounter horizontal gusts and wind shear are illustrated in figure 6.5. As the airplane traverses a shear of wind direction, a change in headwind component will exist. Also, a climbing or descending airplane may traverse a shear of wind velocity, i.e., a wind profile in which the wind velocity varies with altitude.

The response of an airplane is much dependent upon the airplane characteristics but certain basic effects are common to all airplanes. Suppose that an airplane is established in steady, level flight with lift equal to weight, thrust equal to drag, and trimmed so