In this sense, an angle of attack indicator is especially useful for night or instrument takeoff conditions as well as the ordinary day VFR takeoff conditions. Acceleration errors of the attitude gyro usually preclude accurate pitch rotation under these conditions.

FACTORS AFFECTING TAKEOFF PERFORMANCE. In addition to the important factors of proper technique, many other variables affect the takeoff performance of an airplane. Any item which alters the takeoff velocity or acceleration during takeoff roll will affect the takeoff distance. In order to evaluate the effect of the many variables, the principal relationships of uniformly accelerated motion will be assumed and consideration will be given to those effects due to any nonuniformity of acceleration during the process of takeoff. Generally, in the case of uniformly accelerated motion, distance varies directly with the square of the takeoff velocity and inversely as the takeoff acceleration.

$$\frac{S_2}{S_1}=\left(\frac{V_2}{V_1}\right)^2\times\left(\frac{a_1}{a_2}\right)$$

where

S = distance
V = velocity
a = acceleration

condition (1) applies to some known takeoff distance, S_1, which was common to some original takeoff velocity, V_1, and acceleration, a_1.

condition (2) applies to some new takeoff distance, S_2, which is the result of some different value of takeoff velocity, V_2, or acceleration, a_2.

With this basic relationship, the effect of the many variables on takeoff distance can be approximated.

The *effect of gross weight* on takeoff distance is large and proper consideration of this item must be made in predicting takeoff distance. Increased gross weight can be considered to produce a threefold effect on takeoff performance: (1) increased takeoff velocity, (2) greater mass to accelerate, and (3) increased retarding force $(D+F)$. If the gross weight increases, a greater speed is necessary to produce the greater lift to get the airplane airborne at the takeoff lift coefficient. The relationship of takeoff speed and gross weight would be as follows:

$$\frac{V_2}{V_1}=\sqrt{\frac{W_2}{W_1}} \quad (EAS \text{ or } CAS)$$

where

V_1 = takeoff velocity corresponding to some original weight, W_1

V_2 = takeoff velocity corresponding to some different weight, W_2

Thus, a given airplane in the takeoff configuration at a given gross weight will have a specific takeoff speed (*EAS* or *CAS*) which is invariant with altitude, temperature, wind, etc. because a certain value of q is necessary to provide lift equal to weight at the takeoff C_L. As an example of the effect of a change in gross weight a 21 percent increase in takeoff weight will require a 10 percent increase in takeoff speed to support the greater weight.

A change in gross weight will change the net accelerating force, Fn, and change the mass, M, which is being accelerated. If the airplane has a relatively high thrust-to-weight ratio, the change in the net accelerating force is slight and the principal effect on acceleration is due to the change in mass.

To evaluate the effect of gross weight on takeoff distance, the following relationship are used:

the effect of weight on takeoff velocity is

$$\frac{V_2}{V_1}=\sqrt{\frac{W_2}{W_1}} \quad \text{or} \quad \left(\frac{V_2}{V_1}\right)^2=\frac{W_2}{W_1}$$

if the change in net accelerating force is neglected, the effect of weight on acceleration is

$$\frac{a_1}{a_2}=\frac{W_2}{W_1} \quad \text{or} \quad \frac{a_2}{a_1}=\frac{W_1}{W_2}$$