1.32. As with the rectangular wing, the nonuniformity of downwash and lift distribution result in inefficiency of this planform. For example, a pointed wing of $AR=6$ would have 17 percent higher induced angle of attack for the wing and 13 percent higher induced drag than an elliptical wing of the same aspect ratio.

Between the two extremes of taper will exist planforms of more tolerable efficiency. The variations of $\frac{c_l}{C_L}$ for a wing of taper ratio $=0.5$ closely approximates the lift distribution of the elliptical wing and the drag due to lift characteristics are nearly identical. A wing of $AR=6$ and taper ratio$=0.5$ has only 3 percent higher α_i and 1 percent greater C_{D_i} than an elliptical wing of the same aspect ratio.

A separate effect on the spanwise lift distribution is contributed by wing sweepback. Sweepback of the planform tends to alter the lift distribution similar to decreasing the taper ratio. Also, large sweepback tends to increase induced drag.

The elliptical wing is the ideal of the subsonic aerodynamic planform since it provides a minimum of induced drag for a given aspect ratio. However, the major objection to the elliptical planform is the extreme difficulty of mechanical layout and construction. A highly tapered planform is desirable from the standpoint of structural weight and stiffness and the usual wing planform may have a taper ratio from 0.45 to 0.20. Since structural considerations are quite important in the development of an airplane configuration, the tapered planform is a necessity for an efficient configuration. In order to preserve the aerodynamic efficiency, the resulting planform is tailored by wing twist and section variation to obtain as near as possible the elliptic lift distribution.

STALL PATTERNS

An additional effect of the planform area distribution is on stall pattern of wing. The desirable stall pattern of any wing is a stall which begins on the root sections first. The advantages of root stall first are that ailerons remain effective at high angles of attack, favorable stall warning results from the buffet on the empennage and aft portion of the fuselage, and the loss of downwash behind the root usually provides a stable nose down moment to the airplane. Such a stall pattern is favored but may be difficult to obtain with certain wing configurations. The types of stall patterns inherent with various planforms are illustrated in figure 1.33. The various planform effects are separated as follows:

(A) The elliptical planform has constant local lift coefficients throughout the span from root to tip. Such a lift distribution means that all sections will reach stall at essentially the same wing angle of attack and stall will begin and progress uniformly throughout the span. While the elliptical wing would reach high lift coefficients before incipient stall, there would be little advance warning of complete stall. Also, the ailerons may lack effectiveness when the wing operates near the stall and lateral control may be difficult.

(B) The lift distribution of the rectangular wing exhibits low local lift coefficients at the tip and high local lift coefficients at the root. Since the wing will initiate stall in the area of highest local lift coefficients, the rectangular wing is characterized by a strong root stall tendency. Of course, this stall pattern is favorable since there is adequate stall warning buffet, adequate aileron effectiveness, and usually strong stable moment changes on the airplane. Because of the great aerodynamic and structural inefficiency of this planform, the rectangular wing finds limited application only to low cost, low speed light planes. The simplicity of construction and favorable stall characteristics are predominating requirements of such an airplane. The stall sequence for a rectangular wing is shown by the tuft-grid pictures. The progressive flow separation illustrates the strong root stall tendency.

(C) The wing of moderate taper (taper ratio$=0.5$) has a lift distribution which closely