at which equilibrium will occur. As the elevator is fixed in various positions, equilibrium (or trim) will occur at various lift coefficients and the trim CL can be correlated with elevator deflection as in the second graph of figure 4.13.

When the c.g. position of the airplane is fixed, each elevator position corresponds to a particular trim lift coefficient. As the c.g. is moved aft the slope of this line decreases and the decrease in stability is evident by a given control displacement causing a greater change in trim lift coefficient. This is evidence that decreasing stability causes increased controllability and, of course, increasing stability decreases controllability. If the c.g. is moved aft until the line of trim C_L versus elevator deflection has zero slope, neutral static stability is obtained and the "stick-fixed" neutral point is determined.

Since each value of lift coefficient corresponds to a particular value of dynamic pressure required to support an airplane in level flight, trim airspeed can be correlated with elevator deflection as in the third graph of figure 4.13. If the c.g. location is ahead of the stick-fixed neutral point and control position is directly related to surface deflection, the airplane will give evidence of *stick position stability*. In other words, the airplane will require the stick to be moved aft to increase the angle of attack and trim at a lower airspeed and to be moved forward to decrease the angle of attack and trim at a higher airspeed. To be sure, it is desirable to have an airplane demonstrate this feature. If the airplane were to have stick position instability, the airplane would require the stick to be moved aft to trim at a higher airspeed or to be moved forward to trim at a lower airspeed.

There may be slight differences in the static longitudinal stability if the elevators are allowed to float free. If the elevators are allowed to float free as in "hands-off" flight, the elevators may have a tendency to "float" or streamline when the horizontal tail is given a change in angle of attack. If the horizontal tail is subject to an increase in angle of attack and the elevators tend to float up, the change in lift on the tail is less than if the elevators remain fixed and the tail contribution to stability is reduced. Thus, the "stick-free" stability of an airplane is usually less than the stick-fixed stability. A typical reduction of stability by free elevators is shown in figure 4.14(A) where the airplane stick-free demonstrates a reduction of the slope of C_M versus C_L. While aerodynamic balance may be provided to reduce control forces, proper balance of the surfaces will reduce floating and prevent great differences between stick-fixed and stick-free stability. The greatest floating tendency occurs when the surface is at a high angle of attack hence the greatest difference between stick-fixed and stick-free stability occurs when the airplane is at high angle of attack.

If the controls are fully powered and actuated by an irreversible mechanism, the surfaces are not free to float and there is no difference between the stick-fixed and stick-free static stability.

The control forces in a conventional airplane are made up of two components. First, the basic stick-free stability of the airplane contributes an increment of force which is independent of airspeed. Next, there is an increment of force dependent on the trim tab setting which varies with the dynamic pressure or the square of equivalent airspeed. Figure 4.14(B) indicates the variation of stick force with airspeed and illustrates the effect of tab setting on stick force. In order to trim the airplane at point (1) a certain amount of up elevator is required and zero stick force is obtained with the use of the tab. To trim the airplane for higher speeds corresponding to points (2) and (3) less and less nose-up tab is required. Note that when the airplane is properly trimmed, a push force is required to increase airspeed and a pull force is required to decrease airspeed. In this manner, the airplane would indicate positive stick force stability with a stable "feel" for air-