is at a minimum, $(L/D)_{max}$. Thus, for maximum steady-state angle of climb, the turbojet aircraft would be operated at the speed for $(L/D)_{max}$. This poses somewhat of a problem in determining the proper procedure for obstacle clearance after takeoff. If the obstacle is a considerable distance from the takeoff point, the problem is essentially that of a long term gain and steady state conditions will predominate. That is, acceleration from the takeoff speed to $(L/D)_{max}$ speed will be favorable because the maximum steady climb angle can be attained. However, if the obstacle is a relatively short distance from the takeoff point, the additional distance required to accelerate to $(L/D)_{max}$ speed may be detrimental and the resulting situation may prove to be a short term gain problem. In this case, it may prove necessary to begin climb out at or near the takeoff speed or hold the aircraft on the runway for extra speed and a subsequent zoom. The problem is sufficiently varied that no general conclusion can be applied to *all* jet aircraft and particular procedures are specified for each aircraft in the Flight Handbook.

Of greater general interest in climb performance are the factors which affect the ***rate of climb***. The vertical velocity of an airplane depends on the flight speed and the inclination of the flight path. In fact, the rate of climb is the vertical component of the flight path velocity. By the diagram of figure 2.21, the following relationship is developed:

$$RC = 101.3\ V \sin \gamma$$

since

$$\sin \gamma = \frac{T-D}{W}$$

then

$$RC = 101.3\ V\left(\frac{T-D}{W}\right)$$

and,

$$\text{with } Pa = \frac{TV}{325}$$

$$\text{and } Pr = \frac{DV}{325}$$

$$RC = 33{,}000\ \frac{Pa - Pr}{W}$$

where

RC = rate of climb, f.p.m.
Pa = power available, h.p.
Pr = power required, h.p.
W = weight, lbs
V = true airspeed, knots

and

33,000 is the factor converting horsepower to ft-lbs/min
101.3 is the factor converting knots to f.p.m.

The above relationship states that, for a given weight airplane, the ***rate of climb*** (RC) depends on the difference between the power available and the power required ($Pa - Pr$), or excess power. Of course, when the excess power is zero ($Pa - Pr = 0$ or $Pa = Pr$), the rate of climb is zero and the airplane is in steady level flight. When the power available is greater than the power required, the excess power will allow a rate of climb specific to the magnitude of excess power. Also, when the power available is less than the power required, the deficiency of power produces a rate of descent. *This relationship provides the basis for an important* axiom of flight technique: "For the conditions of steady flight, the power setting is the primary control of rate of climb or descent".

One of the most important items of climb performance is the maximum rate of climb. By the previous equation for rate of climb, maximum rate of climb would occur where there exists the greatest difference between power available and power required, i.e., maximum ($Pa - Pr$). Figure 2.21 illustrates the climb rate performance with the curves of power available and power required versus velocity. The power required curve is again a representative airplane which could be powered by either a turbojet or propeller type powerplant. The power available curves included are for a characteristic propeller powerplant and jet powerplant operating at maximum output.

The power curves for the representative propeller aircraft show a variation of propulsive power typical of a reciprocating engine-propeller combination. The maximum rate of climb for this aircraft will occur at some speed