is *cumulative* during cyclic stressing, the useful service life of the aircraft must be anticipated to predict the gross effect of service loads. Then, the primary structure is required to *sustain the typical load spectrum through the* anticipated service life without the occurrence of fatigue failure. To prove this capability of the structure, various major components *must be subjected to an accelerated fatigue* test to verify the resistance to repeated loads.

The design of a highly stressed or long life structure emphasizes the problems of fatigue. Great care must be taken during design and manufacture to minimize stress concentrations which enhance fatigue. When the aircraft enters service operation, care must be taken in the maintenance of components to insure proper adjustment, torquing, inspection, etc., as proper maintenance is a necessity for achieving full service life. Also, the structure must not be subjected to a load spectrum more severe than was considered in design or fatigue failures may occur within the anticipated service life. With this additional factor in mind, any pilot should have *all* the more respect for the operating strength limits—recurring overstress causes a high rate of fatigue damage.

There are many examples of the detrimental effect of repeated overstress on service life. One major automobile manufacturer advertised his product as "guaranteed to provide 100,000 miles of normal driving without mechanical failure." The little old lady from Pasadena—the original owner of ALL used cars —will probably best the guaranteed mileage by many times. On the other hand, the hotrod artist and freeway Grand Prix contender do not qualify for the guarantee since their manner of operation could not be considered *normal*. The typical modern automobile may be capable of 60,000 to 100,000 miles of normal operation before an overhaul is necessary. However, this same automobile may encounter catastrophic failures in a few hundred miles if operated continually at maximum torque in low drive range. Obviously, there are similar relationships for aircraft and powerplant structures.

CREEP CONSIDERATIONS. By definition, creep is the structural deformation which occurs as a function of time. If a part is subjected to a constant stress of sufficient magnitude, the part will continue to develop plastic strain and deform with time. Eventually, failure can *occur from the accumulation of creep damage.* Creep conditions are most critical at high stress and high temperature since both factors increase the rate of creep damage. Of course, any structure subject to creep conditions should not encounter excessive deformation or failure within the anticipated service life.

The high operating temperatures of gas turbine components furnish a critical environment for creep conditions. The normal operating temperatures and stresses of gas turbine components create considerable problems in design for service life. Thus, operating limitations deserve very serious respect since excessive engine speed or excessive turbine temperatures will cause a large increase in the rate of creep damage and lead to premature failure of components. Gas turbines require high operating temperatures to achieve high performance and efficiency and short periods of excessive temperatures can incur highly damaging creep rates.

Airplane structures can be subject to high temperatures due to aerodynamic heating at high Mach numbers. Thus, very high speed airplanes can be subject to operating limitations due to creep conditions.

AEROELASTIC EFFECTS

The requirement for structural stiffness and rigidity is the consideration given to the interaction of aerodynamic forces and deflections of the structure. The aircraft and its components must have sufficient stiffness to prevent or minimize aeroelastic influences in the normal flight range. Aileron reversal, divergence, flutter, and vibration should not occur in the range of flight speeds which will be normal operation for the aircraft.