

Introduction to aeronautics

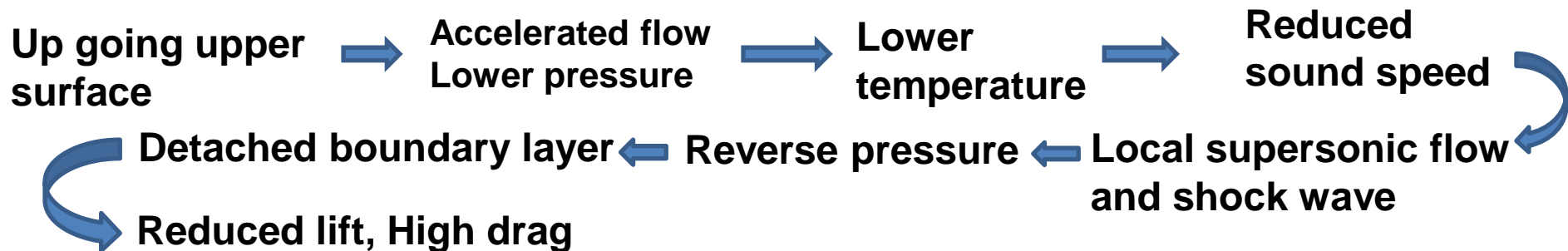
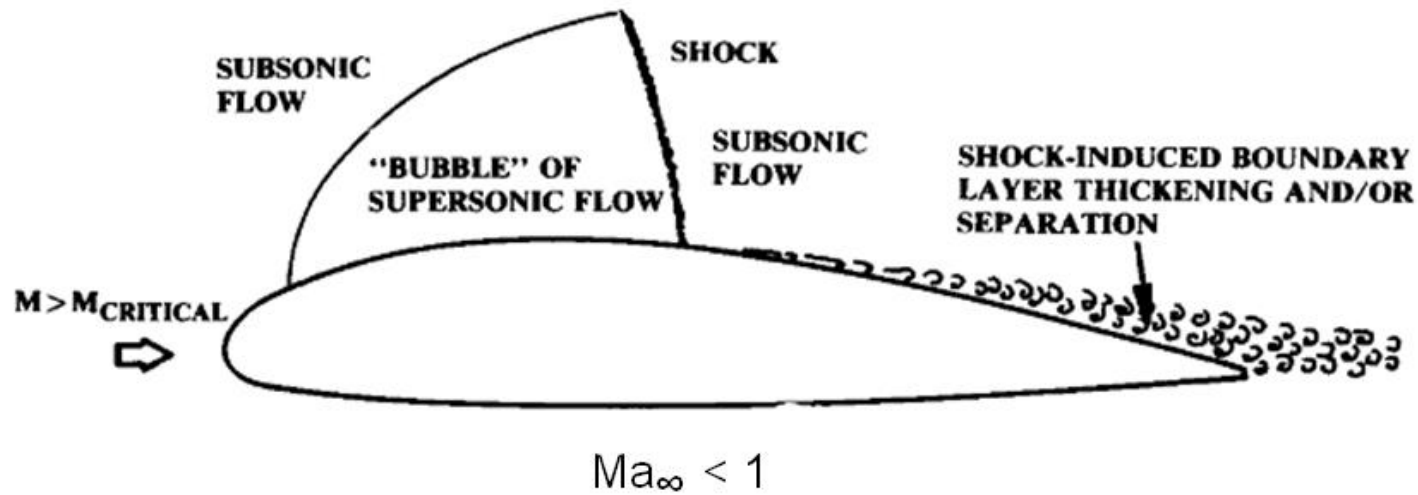
Part 4. The era of the jet-propelled airplane

4.4 The design for breaking sound barrier

- **The key to fly faster than sound**
 - **Reduce the wave drag**
 - **Eliminate flutter**
 - **Solve the problem of reverse control**

4.4 The design for breaking sound barrier

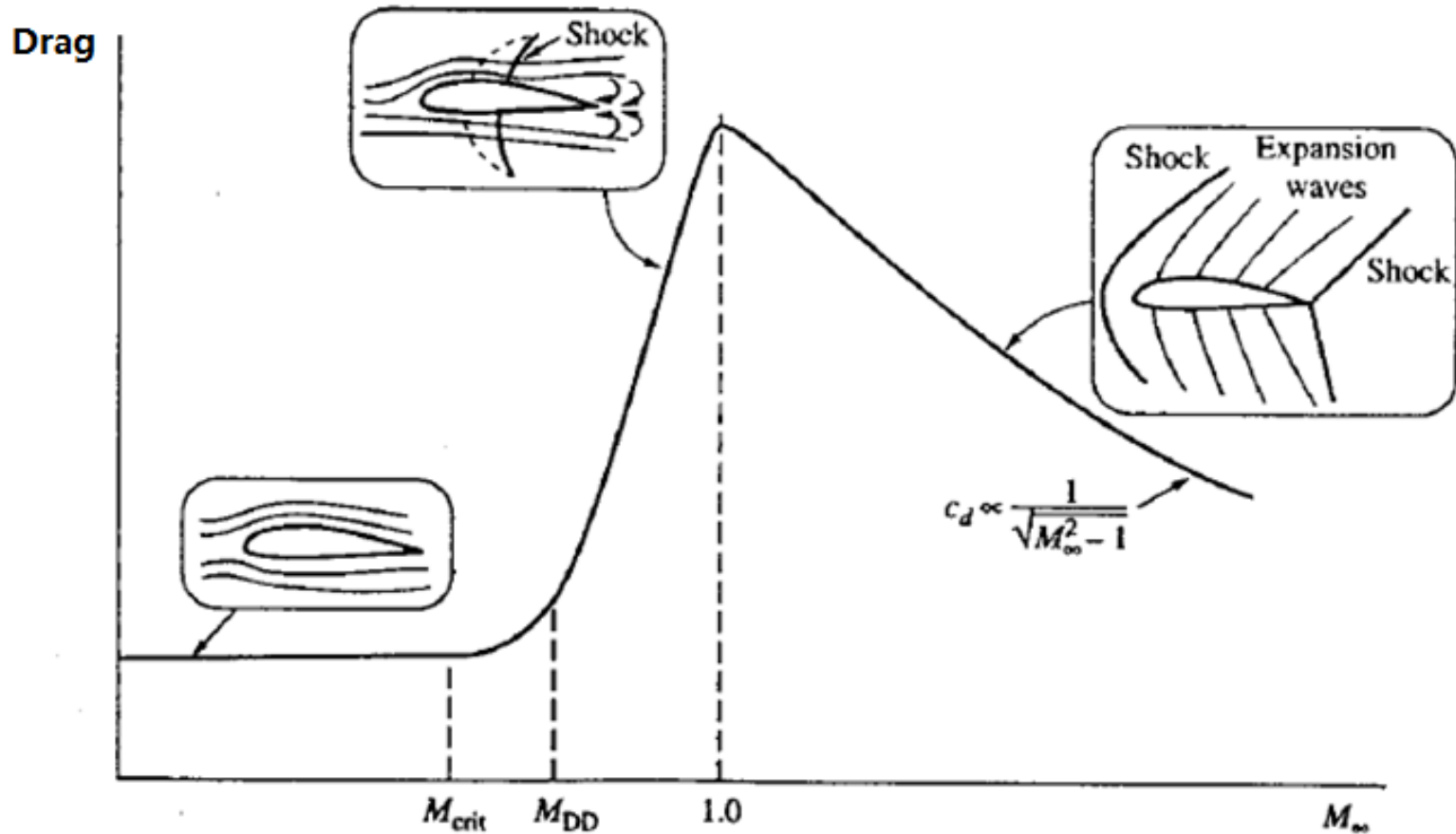
- Reduce the wave drag



Airfoil drag at transonic speed

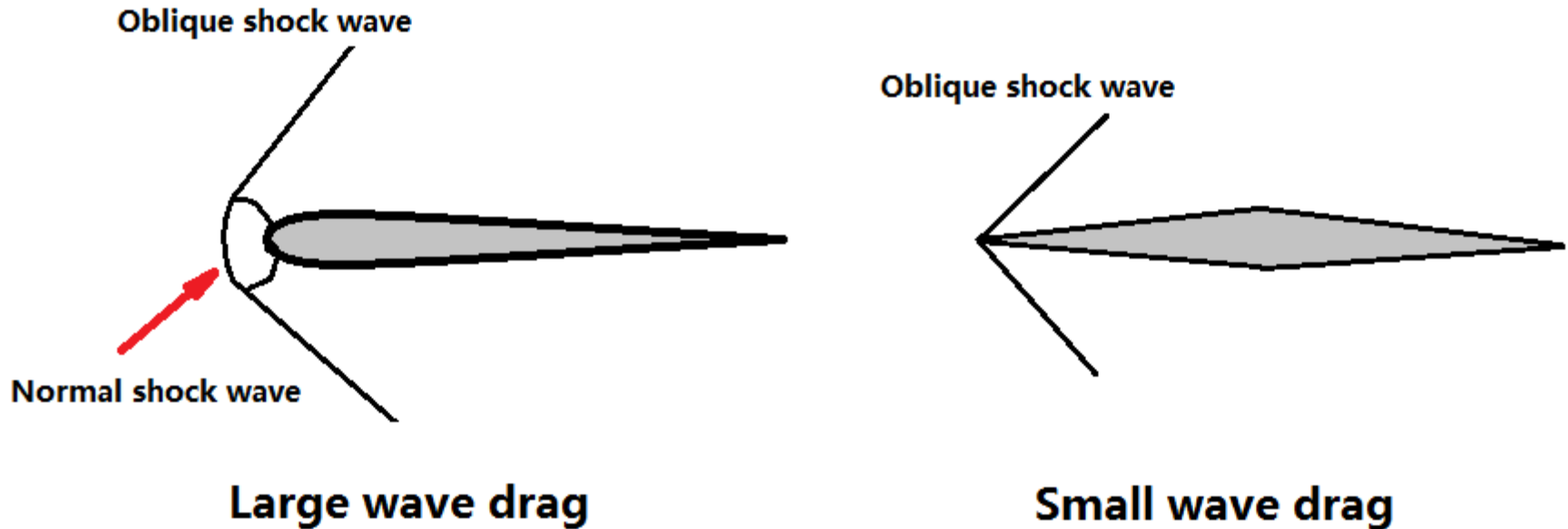
4.4 The design for breaking sound barrier

- Reduce the wave drag



4.4 The design for breaking sound barrier

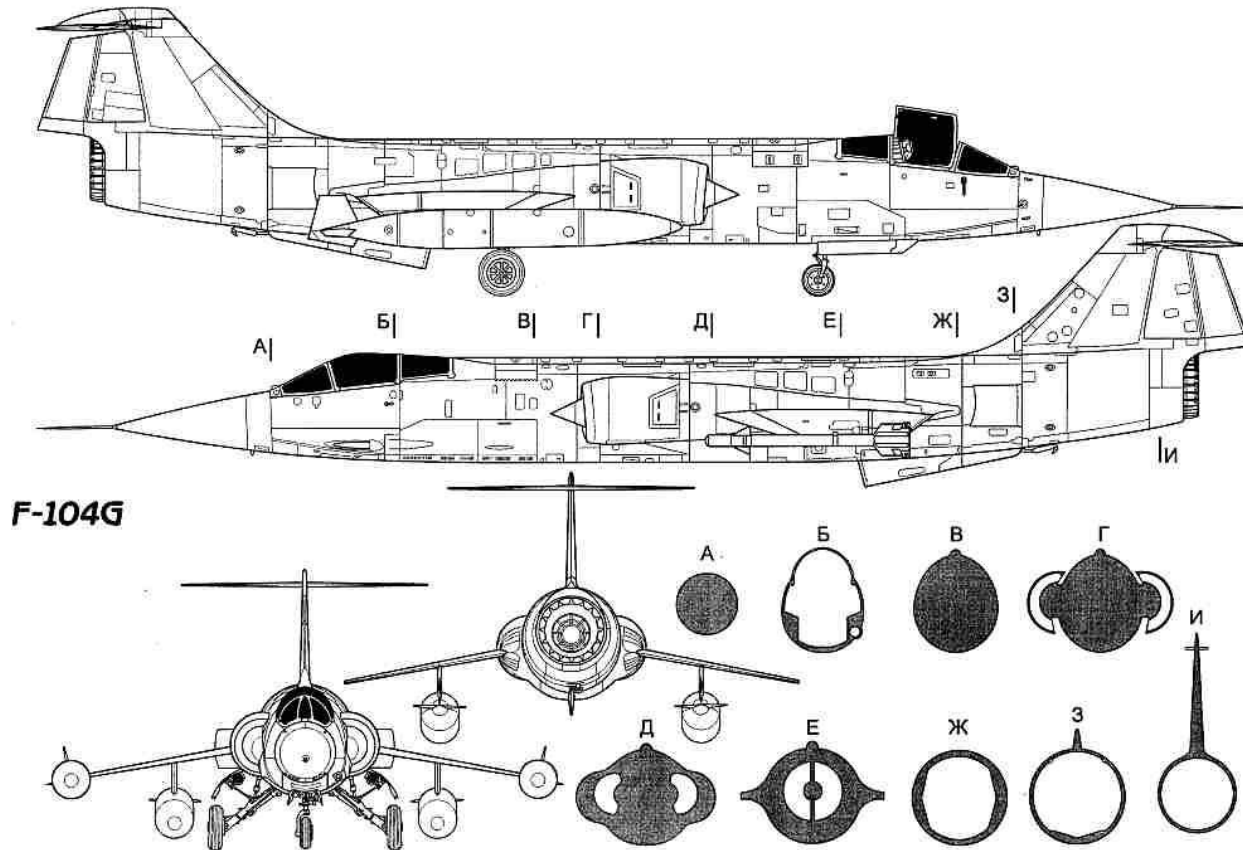
- Reduce the wave drag



Airfoil drag at supersonic speed

4.4 The design for breaking sound barrier

- **Reduce the wave drag**
 - For supersonic aircraft, the thin airfoil with sharp leading edge is used





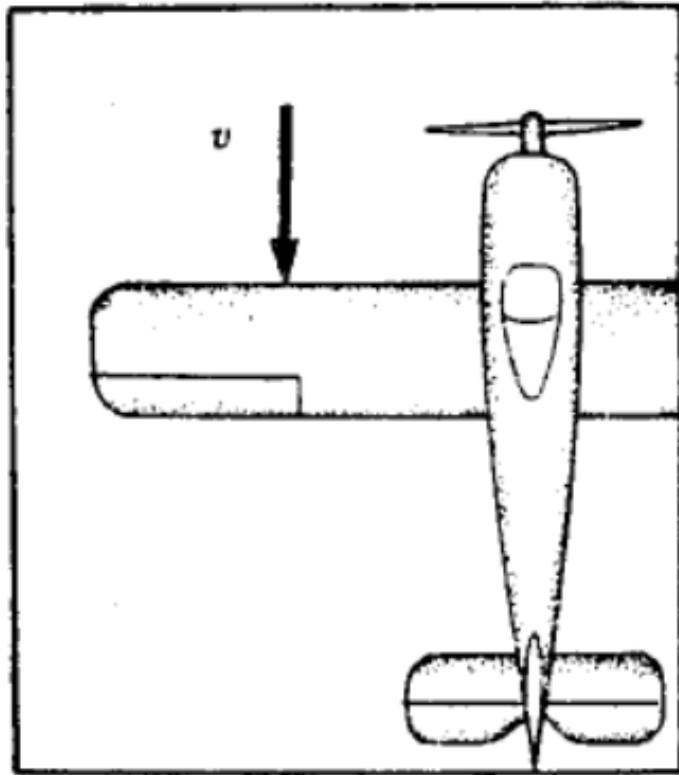
4.4 The design for breaking sound barrier

- **Reduce the wave drag**
 - For transonic flight, the super critical airfoil is used

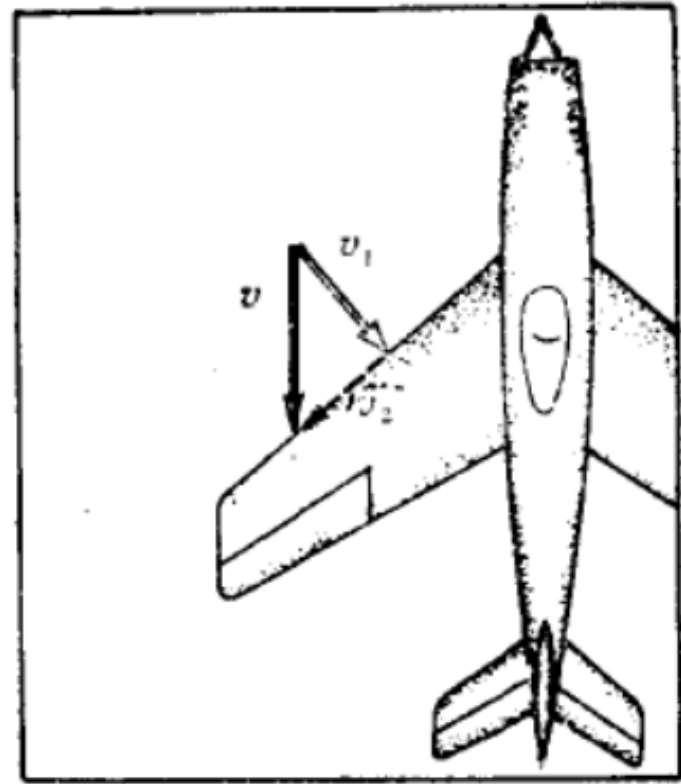


4.4 The design for breaking sound barrier

- **Reduce the wave drag**
 - Swept wing with low aspect ratio



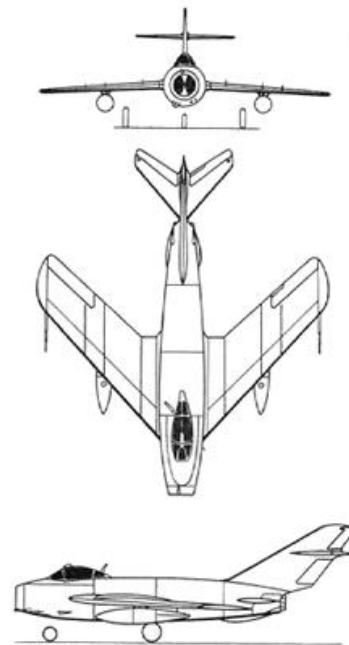
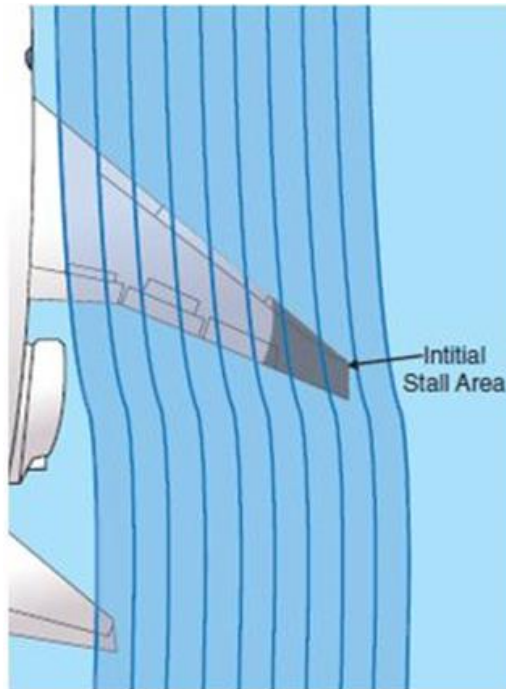
(a)



(b)

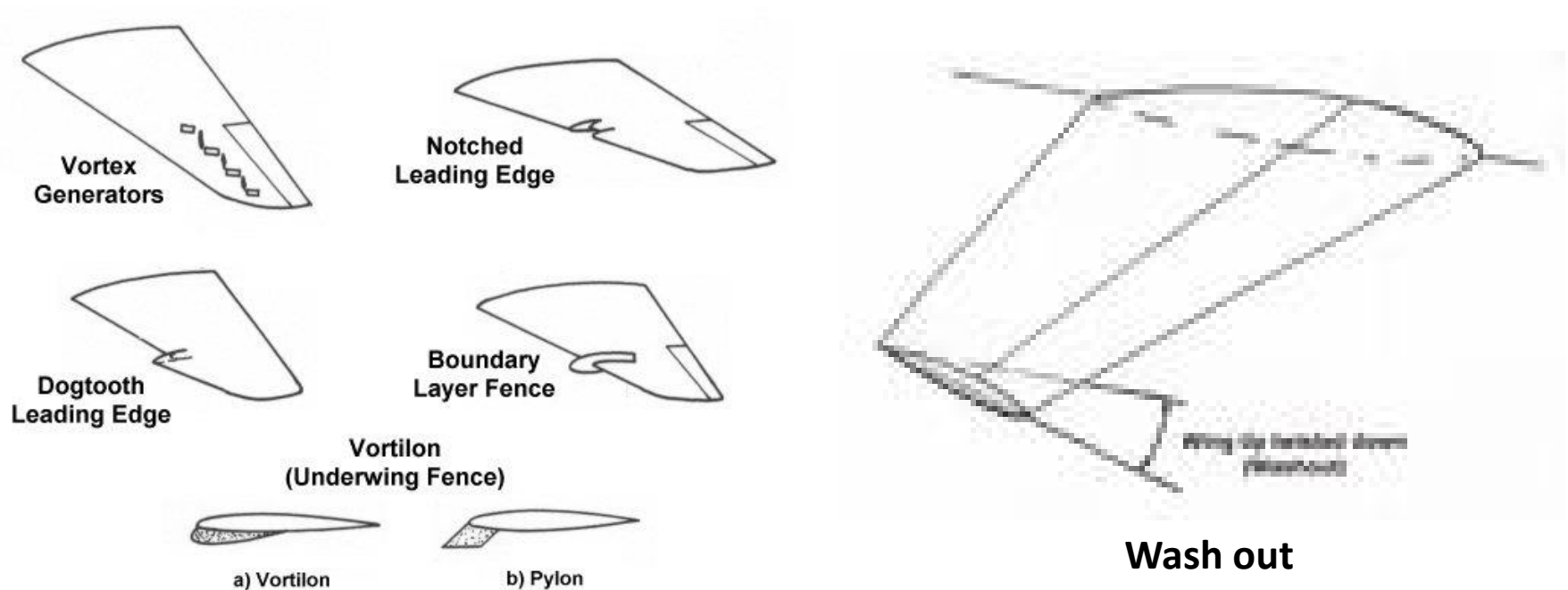
4.4 The design for breaking sound barrier

- **Reduce the wave drag**
 - Sweep back wing has the problem with tip stall
 - When the wing stalled
 - Aircraft will pitch up
 - The aileron will not work
 - Flutter



4.4 The design for breaking sound barrier

- **Reduce the wave drag**
 - Solution of the wing tip stall
 - Leading edge saw tooth
 - Wing fence
 - Vortex generators
 - Wash out



4.4 The design for breaking sound barrier

- **Reduce the wave drag**
 - Solution of the wing tip stall



4.4 The design for breaking sound barrier

- **Reduce the wave drag**
 - Sweep forward wing
 - The aero-elastic problem



Dryden Flight Research Center EC87 0182-14 Photographed 1987
X-29