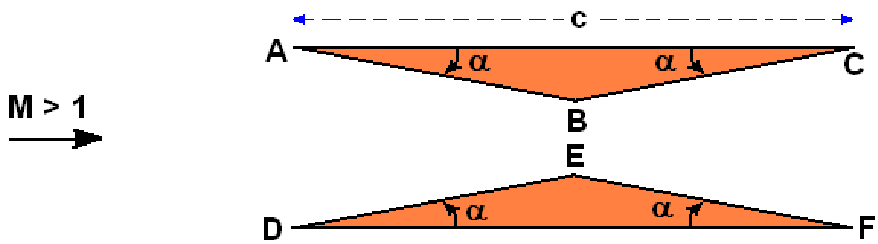
Solution to Problem 340E:

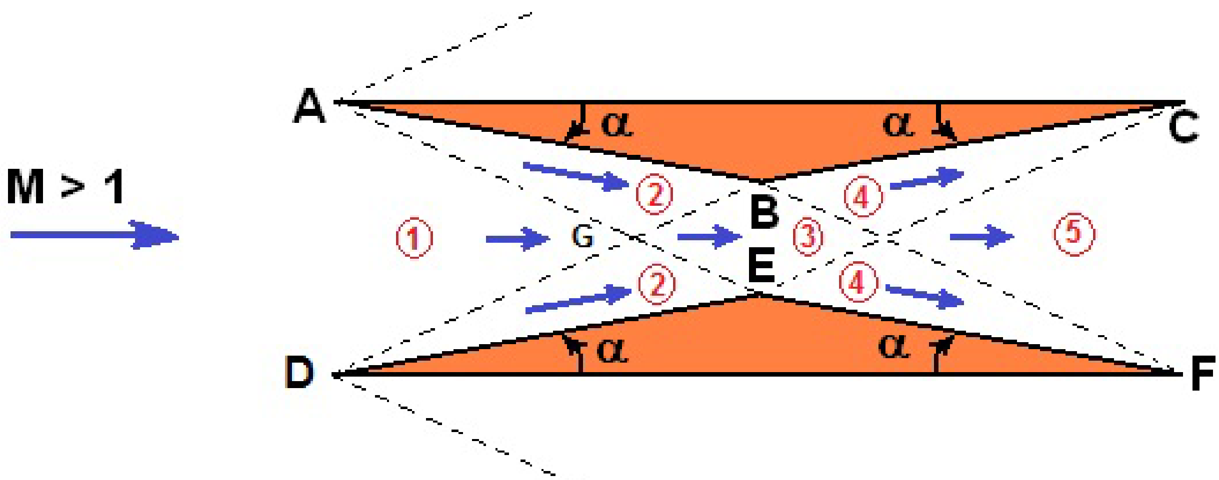
The following biplane arrangement, known as the Busemann biplane, is deployed in a supersonic stream of Mach number, M:



Since the angles B$\hat{\text{D}}$F and E$\hat{\text{A}}$C are both equal to the Mach angle, $\mu = \arcsin(1/M)$, Mach waves emanating from the points A and D will impinge directly on the vertices E and B respectively and since the flows in the regions 2 are compressed by the angle α it follows that the pressures in the regions 2 will be

$$p_2 = p_1 + \Delta p \quad \text{where} \quad \Delta p = \frac{\rho U^2 \alpha}{(M^2-1)^{1/2}} \tag{1}$$

where ρ and U are the density and velocity upstream. But prior to the impingement at E and B the Mach lines emanating from the vertices A and D will intersect at a point labeled G:



Downstream of the point G in region 3 the two flows must be turned so that they are parallel with one another. Therefore region 3 results from a second compression by the angle α so that

$$p_3 = p_1 + 2\Delta p \tag{2}$$

But at the points B and E the flow must again be turned so it is parallel with BC and EF respectively and therefore Mach waves must emanate from B and E as shown above, creating the regions 4 adjacent to the sides BC and EF. Therefore the flow is expanded from region 3 to region 4 by the angle α and therefore

$p_4 = p_2$. Since the pressures are identical on the upstream and downstream sides AB (or DE) and BC (or EF), that is to say in regions 2 and 4, the drag on the biplane is zero. This curious feature was first noted by Busemann and hence the name the Busemann biplane.