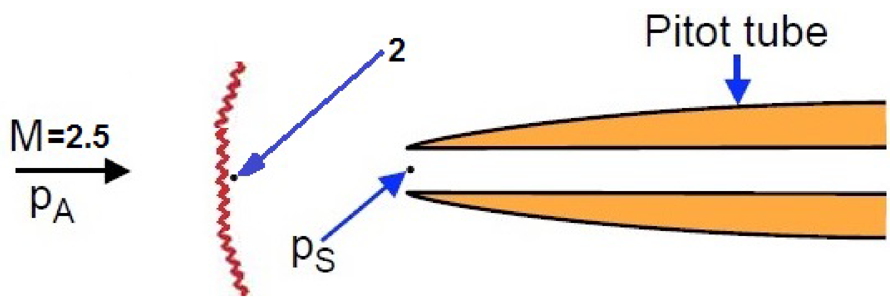
Solution to Problem 334B:

A pitot tube (which senses the stagnation pressure, p_S, at its mouth) is usually incorporated into the nose of a supersonic airplane ($M > 1$) for the purpose of measuring the speed at which the airplane is traveling. Indeed, the ratio of the stagnation pressure, p_S, to the ambient pressure, p_A, of the oncoming flow is directly related to the Mach number, M. As a part of the process by which the flow transitions from $M > 1$ far upstream to zero velocity at the stagnation point, a bow shock (a normal shock wave) forms upstream of the pitot tube. We shall find the pressure ratio, p_S/p_A, when the Mach number $M = 2.5$.



Since the approaching flow is supersonic there will be a shock wave ahead of the Pitot tube and the conditions across this detached shock will be as given in the normal shock wave table. Then, since the Mach number ahead of this shock wave has $M_1 = M = 2.5$ the shock wave table gives the Mach number M_2 immediately downstream of the shock as $M_2 = 0.513$ (where the point 2 is immediately downstream of the shock on the centerline) and $p_2/p_1 = 7.125$ where $p_2 = p_A$. Also $p_{02}/p_{01} = 0.499$.

Since the flow downstream of the shock is subsonic it slows down further as it approaches the Pitot tube so that the velocity at the stagnation point is zero and the stagnation pressure, $p_S = p_{02}$. Also from the isentropic table (or equivalent expression for isentropic flow) we have for $M = 2.5$ that $p_1/p_{01} = 0.059$. Therefore

$$\frac{p_S}{p_A} = \frac{p_{02}}{p_1} = \frac{p_{02}}{p_{01}}\frac{p_{01}}{p_1} = \frac{0.499}{0.059} = 8.46 \qquad (1)$$