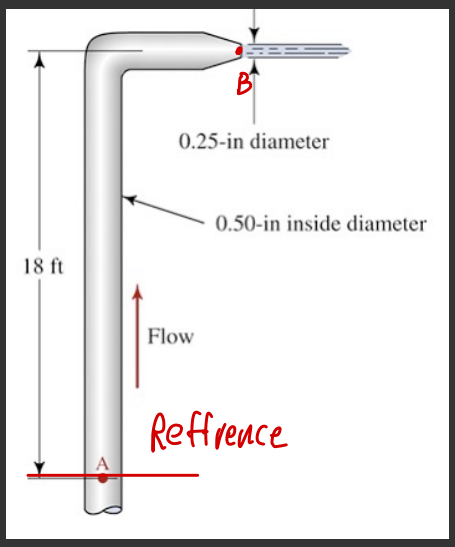
11.13 A device designed to allow cleaning of walls and windows on the second floor of homes is similar to the system shown in the figure. Determine the velocity of flow from the nozzle if the pressure at the bottom is (a) 20 psig and (b) 80 psig. The nozzle has a loss coefficient K of 0.15 based on the outlet velocity head. The tube is smooth drawn aluminum and has an ID of 0.50 in. The 90° bend has a radius of 6.0 in. The total length of straight tube is 20.0 ft. The fluid is water at 100°F.



$$A = \frac{\pi D^2}{4} \qquad A = \frac{\pi \cdot 0.5^2}{4} = 0.1963\ in^2$$

$$Q = V \cdot A \qquad V^2 = \frac{16 Q}{\pi^2 \cdot D^4}$$

$$\frac{V_A^2}{2g} + \frac{P_A}{\gamma} = \frac{V_B^2}{2g} + \frac{P_B}{\gamma} + z_B + h_L$$

$$h_L = K_e \cdot \frac{V_A^2}{2g} + K_n \cdot \frac{V_A^2}{2g} + f \cdot \frac{L}{D^5} \cdot \frac{V_A^2}{2g}$$

$$\frac{\Delta P}{\gamma} - z_B = \left(K_e + K_n + f \cdot \frac{L}{D}\right) \frac{8 Q^2}{g \cdot \pi^2 D^4}$$

LHS:

$$\frac{\Delta P}{\gamma} - z_B$$

RHS:

$$\left(K_e + K_n + f \cdot \frac{L}{D}\right) \frac{8 Q^2}{g \cdot \pi^2 D^4}$$

P_a=	20	psig	2880	lb/ft^2			
P_b=	0	psig	0	lb/ft^2			
z_b=	18	ft					
ν=	7.37E-06	ft2/s					
g=	32.2	ft/s2					
γ=	62	lbf/ft3					
K_valve=	0.15	ft					
K_elbow=	20						
ε	5.00E-06	ft					
L=	20	ft					
Diameter_A	0.041666667	ft					
Diameter_B	0.020833333	ft		V_2			
Area_A	0.001363538	ft^2		18.92			
Area_B	0.000340885	ft^2					
LHS=	28.4516129						

Iteration	V_A	Q (ft3/s)	Re	D/ε	f	RHS	%diff
1	4	0.005454	2.26E+04	8.33E+03	0.02535	15.1366	-46.8%
2	5	0.006818	2.83E+04	8.33E+03	0.02407	35.07769	23.3%
3	4.5	0.006136	2.54E+04	8.33E+03	0.02466	23.58241	-17.1%
4	4.6	0.006272	2.60E+04	8.33E+03	0.02453	25.61804	-10.0%
5	4.7	0.006409	2.66E+04	8.33E+03	0.02441	27.78037	-2.4%
6	4.75	0.006477	2.69E+04	8.33E+03	0.02435	28.9106	1.6%
7	4.73	0.00645	2.67E+04	8.33E+03	0.02438	28.45452	0.0%

$$V_2 = Q / A$$

$$V_2 = 0.00645 / 0.000340885$$

$$V_2 = 18.92\ ft/s$$

11.13 $P_A = 80$ psi;

P_a=	80	psig	11520	lb/ft^2			
P_b=	0	psig	0	lb/ft^2			
z_b=	18	ft					
ν=	7.37E-06	ft2/s					
g=	32.2	ft/s2					
γ=	62	lbf/ft3					
K_valve=	0.15	ft					
K_elbow=	20						
ε	5.00E-06	ft					
L=	20	ft					
Diameter_A	0.041666667	ft					
Diameter_B	0.020833333	ft		V_2			
Area_A	0.001363538	ft^2		30.268			
Area_B	0.000340885	ft^2					
LHS=	167.8064516						

Iteration	V_A	Q (ft3/s)	Re	D/ε	f	RHS	%diff
1	8	0.010908	4.52E+04	8.33E+03	0.02170	207.245	23.5%
2	7	0.009545	3.96E+04	8.33E+03	0.02233	125.0094	-25.5%
3	7.5	0.010227	4.24E+04	8.33E+03	0.02200	162.3076	-3.3%
4	7.6	0.010363	4.30E+04	8.33E+03	0.02193	170.6543	1.7%
5	7.55	0.010295	4.27E+04	8.33E+03	0.02197	166.4423	-0.8%
6	7.56	0.010308	4.27E+04	8.33E+03	0.02196	167.2785	-0.3%
7	7.567	0.010318	4.28E+04	8.33E+03	0.02195	167.8657	0.0%

$V_B = 30.268$ ft/s