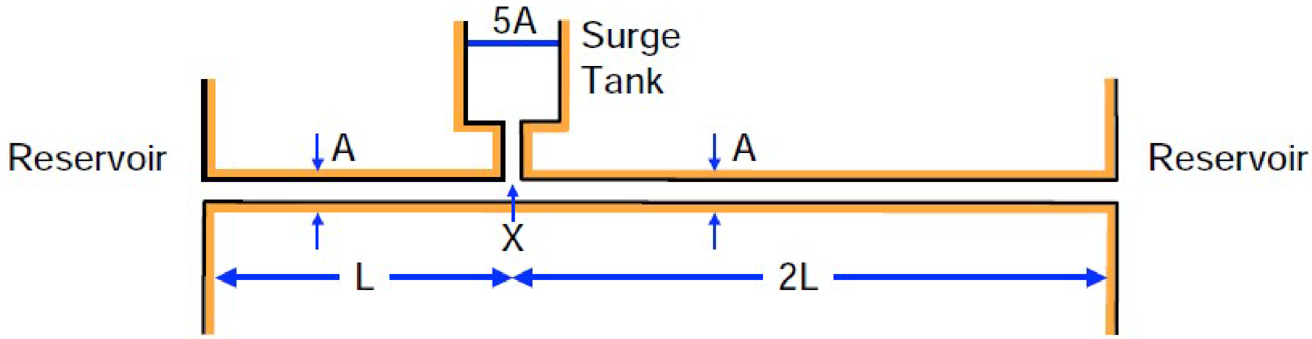
Solution to Problem 210E:

One large reservoir of incompressible liquid is connected by a pipeline (cross-sectional area = A, length = $3L$) to another large reservoir:



Let the flowrates in the pipelines of lenght L and $2L$ be denoted bu Q_1 and Q_2 respectively. Now consider only unsteady deviations from the mean flow rates and total heads. Let the unsteady deviation of fluctuation in the total head at the junction X be denoted by H. Since the fluctuations in the total head in both reservoirs are negligible, the inertance in the two pipelines leads to the following two equations for the unsteady flows in the two pipelines:

$$g(0 - H) = \frac{L}{A}\frac{dQ_1}{dt} \quad \text{and} \quad g(H - 0) = \frac{2L}{A}\frac{dQ_2}{dt} \tag{1}$$

But the compliance of the surge tank is $5A/g$ so that

$$Q_1 - Q_2 = 5A\frac{dH}{dt} \tag{2}$$

Combining this with the first equations:

$$-\frac{3}{2}\frac{Ag}{L}H = 5A\frac{d^2H}{dt^2} \tag{3}$$

and therefore the frequency is $(3g/10L)^{1/2}$.