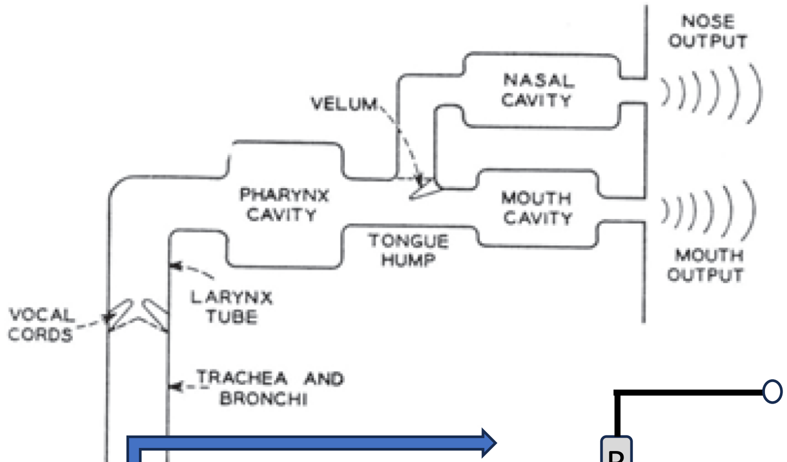
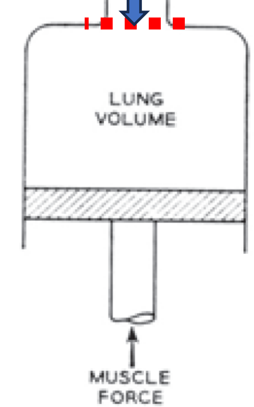
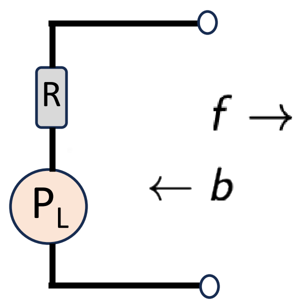
Explanation of the lung termination in LeTalker





1. We assume the lung termination to be at the bronchi and is approximated as a pressure source P_L and a resistance R to flow. This approximation ignores all of the interesting wave propagation in the branching of the bronchi, but likely doesn't make a lot of difference for our interests at the VFs and beyond.



2. The f and b here are at the itrch index in LeTalker.

3. The pressure across the terminals is "P" and equal to P_L minus R * U, which is equal to f +b

$$P = P_L - RU = f + b$$

4. But the flow is equal to this where Z_0 is the characteristic acoustic impedance of the tube at this location:

$$U = \frac{1}{Z_0}(f - b)$$

5. Substituting this into the first eqn gives:

$$P_L - \frac{R}{Z_0}(f - b) = f + b$$

6. Solving for f

$$f = \frac{P_L}{1+\frac{R}{Z_0}} - b\left(\frac{1-\frac{R}{Z_0}}{1+\frac{R}{Z_0}}\right)$$

7. Now here's the leap. We estimate the ratio of R/Z_0 to be 0.1. That's a guess based the input impedance that can be calculated looking into the trachea from the level of the VFs. We've found the calculated impedance to be close to measured impedances. See next page for example.

$$\frac{R}{Z_0} = 0.1$$

8. This also means that at the first time instant the initial forward partial pressure f is 90% of the P_L, and the effective reflection coefficient at the termination is -0.8 (similar to an open-end condition of a tube which is correct because of the drastic increase in effective area due to branching in the resp system)

$$f = 0.9P_L - 0.8b$$

B. Story, 09.13.2024

Subglottal system input impedance (measured)
from Ishizaka, Matsudaira, and Kaneko (1976)

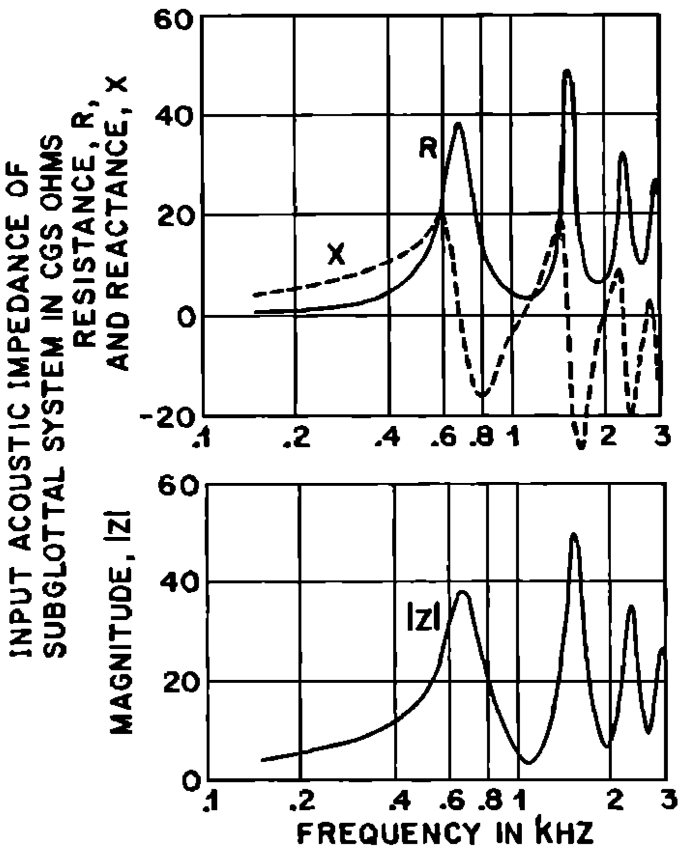


FIG. 3. A measured input acoustic impedance looking from the opening into the trachea, including the parallel impedance of the upper cavity.