POLITECNICO
MILANO 1863

MSc. Music and Acoustic Engineering

Musical Acoustics - A.Y. 2020/2021

H4 - Impedance maxima of a compound horn

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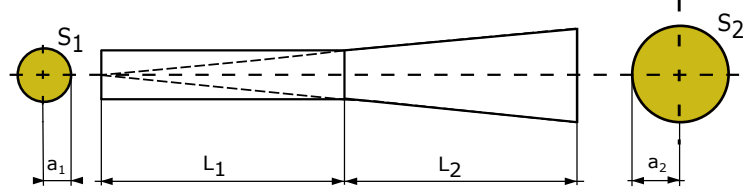# 1 Impedance maxima of the pipe

Figure 1: Scheme of the compound horn system.

In order to compute the acoustic input impedance of a pipe, one needs to account not only for the air contained in the pipe as an ideal fluid but also for two phenomena occurring around it: the radiation load at the end and the wall losses along its length. The latter is relevant for narrow pipes in particular, but in this case, since the ratio between the pipe's length and the radius of its cross section is $L_1/a_1 = 10$, it is clear that we are not dealing with this condition. Moreover, a common way to characterize the influence of the viscous drag is the ratio of the pipe radius with the boundary layer thickness r_v. If this parameter is greater than 10, it is usually considered safe to neglect the wall losses. Since $r_v \propto \sqrt{f}$, this might not be true at low frequencies; however, in our case, we can see that r_v increases very rapidly from zero and at $1\,\mathrm{Hz}$ is already ~ 30. We assume, therefore, that it is safe for us to ignore such losses in the computation of the impedance.

Concerning the radiation, instead, we know that its influence on an open-ended pipe is usually not negligible. At low frequency, the strategy that is commonly used to address the study of radiation is to add an end correction Δ^{open}. At first order in ka the radiation impedance of an open end is equal to the input impedance of an open pipe of length Δ^{open}. We take the value $\Delta^{open} = 0.61a$; this holds well under the assumption $ka \ll 1$