The Action of a Helmolts Resonator in a Branch Line

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If, however, $Z^4$ be defined as the ratio between the pressure and the rate of volume displacement in the branch, the ratio of incident to transmitted energy can be shown to be:

$$Z^4 = \frac{\left( Z_1 - \frac{\rho a}{2s} \right)^2 + Z_3^2}{Z_1^2 + Z_3^2}$$

(2)

Consider a general case where the attached vessel has a point impedance, $Z_a$, this referring to a point just within the vessel. Denoting this by $Z_a$, the incident pressure $P$ at the opening can be expressed as:

$$\frac{\rho a}{c} X + \frac{\rho a}{2s} X + Z_a X = P$$

(3)

From this it can be shown that the ratio of transmitted to incident energy is:

$$\frac{Z_a^2 + \left( \frac{k \rho a}{c} Z_{a2} \right)^2}{Z_a^2 + \left( \frac{k \rho a}{2s} \right)^2 + \left( \frac{k \rho a}{c} + Z_{a2} \right)^2}$$

(4)

wherein $k$ is $2\pi$-wavelength and $c$ is the conductivity of the orifice. This is a general formula and has been tested in the case of a cylindrical resonator, a Helmholtz resonator and a simple orifice. In any branch in general, let there be two unknown quantities $Z_1$ and $Z_2$. It is possible to measure the ratio in (4) with conduits of various areas $s$ and thus to obtain the values of $Z_1$ and $Z_2$ separately assuming that $c$ is known.

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The general impression of a Helmholtz resonator is that, since its dissipation is small, its tuning is fairly sharp. It is noted with some surprise, therefore, that when used as a side branch in an acoustic transmission line it affects the transmission over a wide range of frequencies. The theory, derived from the general case in the preceding abstract has been checked by experiment with resonators of varying dimensions and the theory verified to a very satisfactory degree.

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