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The Physics of Brasses

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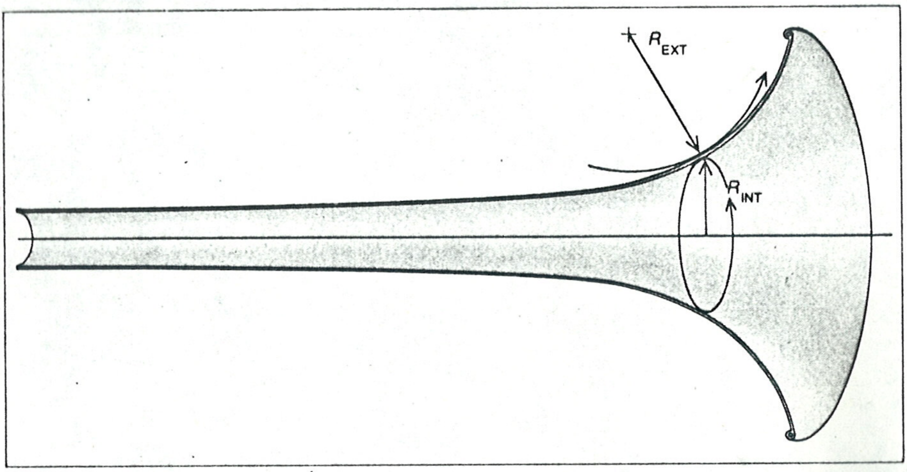


a

$$U \cong \frac{1}{R_{INT} \times R_{EXT}}$$

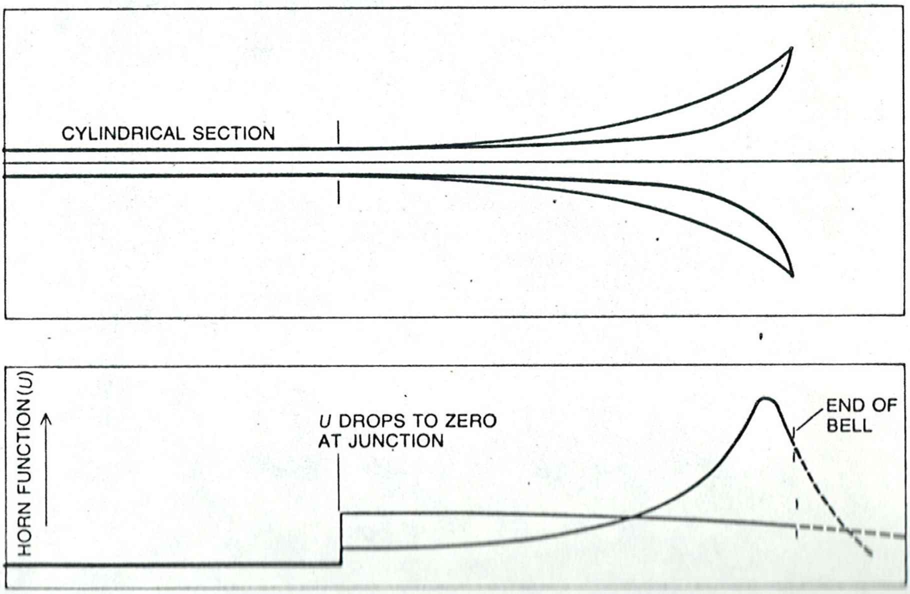
b

$$\lambda = \frac{c}{\sqrt{f^2 - U(c/2\pi)^2}}$$

c

$$\lambda = \frac{h}{\sqrt{E - V}}$$

GEOMETRY OF HORN FLARE largely governs the pitch and timbre of sounds produced by horns of the trumpet and trombone family. As a sound wave travels into the flaring bell of the horn its pressure falls steadily as the cross section of the instrument increases. A "horn function," U, determines how much of the acoustic energy leaves the horn and how much is reflected back into the horn to produce standing waves inside the instrument. The horn function (*equation "a"*) is approximately equal to 1 over the product of the internal radius (R_{int}) of the horn and the external radius (R_{ext}) at any given point. The simplified form of the horn equation (*equation "b"*) gives the acoustic wavelength (λ) at any point in the horn, where f is the sound frequency and c is the velocity of sound. This velocity varies with U and f. The horn equation has the same form as the celebrated Schrödinger equation (c), which shows how the de Broglie wavelength (λ) of a particle of energy E is related to Planck's constant (h) and the potential energy function V at any point in space.



TROMBONE BELL AND LOUDSPEAKER HORN are markedly different in geometry and acoustic properties. The catenoidal shape (*black curve at top*) of the loudspeaker horn favors the efficient radiation of sound into the air. The flaring shape (*colored curve at top*) of the trombone bell is designed to save energy inside the horn, thus generating strongly marked standing waves at closely defined frequencies. Both the trombone bell and the loudspeaker horn are shown attached to a short section of cylindrical pipe. The two curves at the bottom show the horn function, U, for each horn. The catenoidal horn has a horn function (*colored curve*) that is low and nearly constant except for a slight falling off at the large end, where the sound wave fronts begin to bulge appreciably. The horn function (*black curve*) of the trombone bell rises steeply and falls. The higher the value of the function U, the higher the barrier to sounds of low frequency. Sounds of higher frequency are able to progress farther before they are reflected back by the barrier. In both cases above a certain frequency most of the sound energy radiates over the top of the barrier, so that the bell of the trombone loses its musically useful character and behaves like a loudspeaker horn.