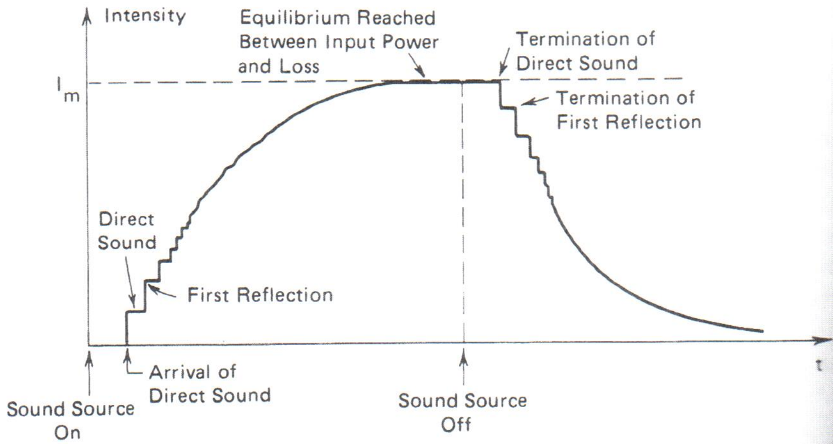

FIGURE 4.27 Typical tone intensity buildup and decay in a hall (linear scale).

of 1.5–2 s. Longer times would blurr too much typical tone successions; shorter times would make the music sound "dry" and dull (see Sec. 4.8).

We may discuss a few simple mathematical relationships that appear in room acoustics. Let us imagine an enclosure of perfectly reflecting walls with no absorption whatsoever, but with a built-in *hole* of area A. Whenever the maximum intensity I_m is reached (Fig. 4.27), acoustical energy will be escaping through the hole at a rate given by the product I_mA.[16] Since this corresponds to the steady state in which the power P supplied by the instrument equals the energy loss rate, we can set $P = I_mA$, or

$$I_m = \frac{P}{A} \quad (4.9)$$

In a real case, of course, we do not have perfectly reflecting walls with holes in them. However, we still may *imagine* a real absorbing wall as if it were made of a perfectly reflecting material with holes in it, the latter representing a fraction a of its total surface. a is called the *absorption coefficient* of the wall's material. A surface of S square meters, of absorption coefficient a, has the same absorption properties as a perfectly reflecting wall of the same size but with a hole of area $A = Sa$. Absorption coefficients depend on the frequency of the sound (usually increasing for higher frequencies), and have values that range from 0.01 (marble: an almost perfect reflector) to as much as 0.9 (acoustical tiles). Taking all this into account, we can rewrite relation (4.9) in terms of the actual wall surfaces $S_1, S_2, \ldots$ with corresponding absorption coefficients $a_1, a_2, \ldots$

[16] It is assumed here that I_m, represents the diffuse, *omni*directional sound energy flow.

$$I_m = \frac{}{S_1a_1 + S}$$

This relation can be used to estimate
wanted values of I_m, for a given instru
bution of absorbing wall materials.

The reverberation time τ_r is found t
of the hall and inversely proportional
$A = S_1a_1 + S_2a_2 + \cdots$. Experiments s

$$\tau_r = 0.16\frac{}{S_1a_1 +}$$

with V in cubic meters, S in square m
absorption coefficients usually increas
decrease with increasing pitch: bass no
notes.

One of the problems in room acou
influences (increases) the absorption p
taken into account in the design of aud
effects related to the unpredictable si
distribution, it would be necessary to
coefficient is nearly independent of wh
absorbing effect of the audience is max
long reverberation times, such as in ch
performer is so exposed to (and har
environment as an organist.

Tone distribution, buildup, and dec
pendence of the absorption coefficient
physical characteristics of musical tones
environment, hence on the perception o
dependence of tones is deeply affect
altered, and, for instance, a staccato
depending on the reverberation properti
is also affected, since the absorption c
pendent. Finally, taking into account tha
through a given point in a field of reverb
it can be shown that the resulting SPL c
also fluctuate at random, introducing a
recognized timbre in a closed mus
Meyer-Eken, 1973).

There are other second-order effects.
the phenomenon called *diffraction*. Wh
a pillar in a church or a person sitt
situations may arise: (1) If the wavelen
larger than the size (diameter) of the c