area of all branches leaving the junction. Generally the total area of the branches leaving a junction is greater than that of the duct entering a junction; therefore, the area of the branch should not be divided by the area of the supply duct. In a complicated branched system, errors incurred by such a practice may accummulate to several db. Table 4 gives the db reduction for various ratios of branch duct area to total branch duct area.

Square Corner Bends

Square corner bends can be quite effective in noise reduction provided they are widely separated in the system. The noise reduction for a single square corner bend with no turning vanes, unlined is shown in Fig. 8 Part A. Turning vanes are usually employed in square corner ducts. When the width of the turning vanes is small, say less than one-fourth wavelength of the sound, they do not affect the noise reduction. At higher frequencies, they decrease the noise reduction substantially below that shown in Fig. 8 Part A.

When a square corner bend is lined with sound absorbing material, the lining should be extended several duct widths beyond the corner in the direction of sound transmission. For square bends lined in this manner the attenuation may be estimated from Fig. 8 Part B.

Table 4. Power Level Attenuation at Duct Branches or Outlets

Ratio Branch Duct Area / Sum of Branch Areas	Attenuation db
1.0	0
0.8	1
0.63	2
0.5	3
0.4	4
0.32	5
0.25	6
0.2	7
0.16	8
0.13	9
0.1	10

End Reflection Losses

All of the noise power that is produced in a duct by a fan (or by turbulence) does not radiate from the end of a duct into the room. Instead, part of the power is reflected back from the end toward the fan. The amount of noise power reflected is related to the product of the frequency of the sound and the length of a duct side L, assuming that the duct is square. If the duct is not square, the value of L is taken to be approximately equal to $\sqrt{L_x L_y}$. The end reflection loss is shown in Fig. 9 for two cases: (1) a duct ending in free space and (2) a duct ending flush with the wall.

Duct Lining Procedure

In the past, the most common method of obtaining sound absorption in ventilating systems has been to line the duct with absorbing material. It is usually more convenient to line all four sides of the duct, but a lining on one side over a longer length of the duct will, in general, give the same effect for the same area of applied acoustical material. Subject to certain restrictions, the attenuation of a fully lined duct to single-frequency sounds may be expressed by the approximate Equation 22.[9]

$$R = 12.6l \frac{P}{A} \alpha^{1.4} \text{ db} \quad (22)$$

here

R = attenuation, decibels.

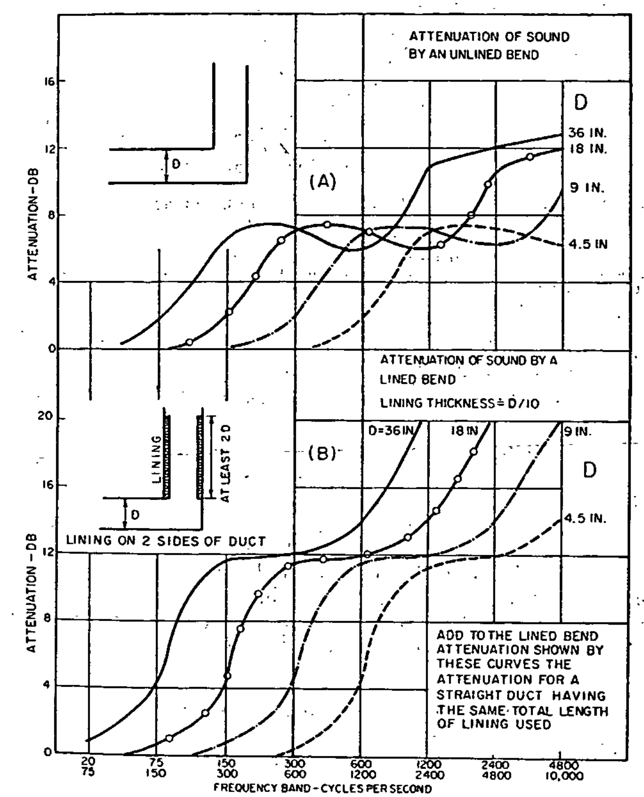

Fig. 8. Attenuation in Decibels Provided by (A) Unlined Bend, and (B) Lined Bend in a Duct with the Lateral Dimension D

The attenuation is given for eight octave frequency bands with D in inches as the parameter.

l = length of lined duct, feet.
P = perimeter of duct, inches.
A = cross-sectional area of duct, square inches.
α = absorption coefficient of lining (a function of frequency).[10]

This formula was empirically developed for a set of duct sizes ranging from 9× 9 in. to 18× 18 in.; for cross-sectional dimension ratios of 1:1 to 2:1; for frequencies between 256 and 2048 cycles; and for absorption coefficients between 0.20 and 0.80. The duct lining material used was 1 in.