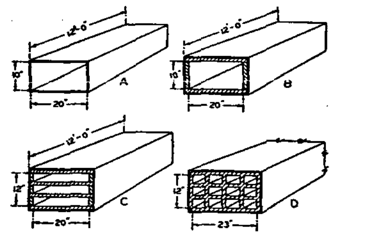


A. Unlined metal duct
B. Lined duct
C. Splitter plate type absorber
D. Cell-type absorber

The open area is the same for each case shown if 1 in. thick absorption material is assumed.

Fig. 10 . . . . Acoustic Treatment of Ducts

absorption, are so unpredictable that flexural vibration cannot be relied upon for a specific value of attenuation.

3. It has been shown[20] that increased attenuation at frequencies below 700 cps may be realized by using a perforated facing in which the area of the perforations is from 3 to 10 percent of the surface area.

Requirements for a good sound absorption material are: (1) high absorption at low frequencies;[16] (2) adequate strength to avoid breakage; (3) fire resistance and compliance with national and local code requirements; (4) low moisture absorption; (5) freedom from attack by bacteria and algae; (6) low surface coefficient of friction; (7) particles should not fray off at the higher design velocities; and (8) freedom from odor when either dry or wet.

Rectangular Cells (Plate or Cell Absorbers)

If the available length of duct between the main duct (or the fan) to the grille is shorter than the length of lining indicated as necessary by Equation 21, the duct may be subdivided into smaller ducts as shown in Fig. 10, or it can also be even more subdivided by an egg-crate construction. In such a construction in which all the subdivided ducts are the same size, sound will be equally absorbed down each channel. It is, therefore, only necessary to calculate the sound attenuation of an individual channel. For this, Equation 21 is adequate, assuming that the thickness of the material is halved if it forms a common splitter between two cells.

When the number of splitter plates or cell partitions is large, the percentage free area of the gross duct size may be materially reduced. This leads to a further sound attenuation. Values of the attenuation possible, due to this cause, are given in Table 7.

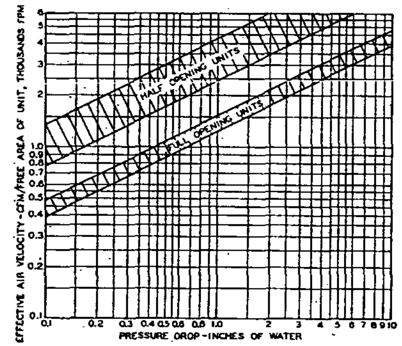


Fig. 11 . . . . Typical Values of Static Pressure Drop Through Sound Traps

Table 7 . . . . End Reflection of Plate or Cell Absorbers

Percentage Free Area of Absorber	50	40	30	25	20
Attenuation db	1	2	4	5	6

Package Units

Package units for attenuating sound in ducts are coming more and more into common use. These units have the advantage of providing, in a short length, a known amount of noise reduction with a minimum opportunity for errors in installation and for erosion of materials. The cost of inspection of the completed job is eliminated and the outside dimensions of the duct can be reduced as compared to a lined duct.

These units are available in sizes to fit 6 x 12 in. ducts up to 80 x 84 in. ducts. Charts are supplied by the manufacturers giving the attenuations and pressure drops for different types.

In Fig. 11, the static pressure drops for several types of package units are shown. Typical attenuation ratings are shown in Table 8. Manufacturers' literature should be consulted for exact values.

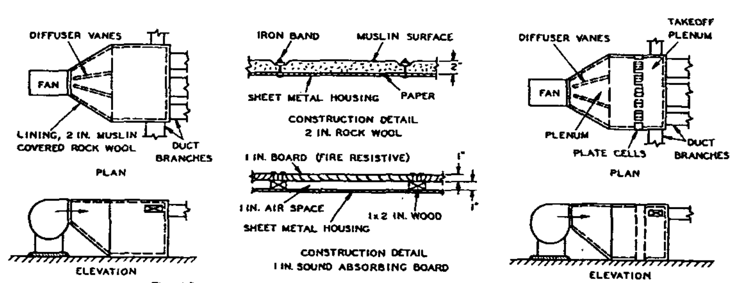
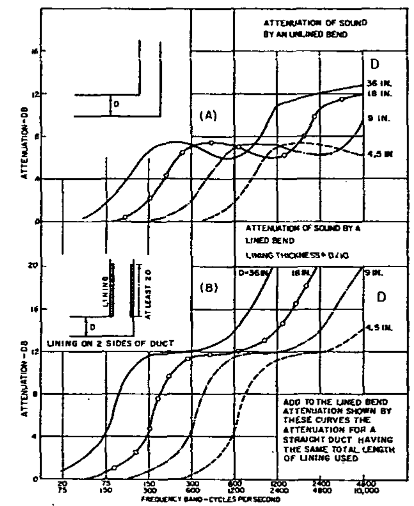


Fig. 12 . . . . Absorption Plenums With and Without Sound Cells

Table 8 . . . . Typical Values of Sound Attenuation in Decibels for Sound Traps*

Octave Band, cps	Half-Opening Units, Length, ft				Full Opening Units, Length, ft		
	2	3	5	8	4	6	8
37.5–75	9	10	11	13	7	9	11
75–150	10	11	12	14	9	11	15
150–300	12	16	20	26	11	17	24
300–600	15	19	26	35	18	26	33
600–1200	25	31	45	59	30	45	56
1200–2400	36	46	56	63	40	56	62
2400–4800	29	39	49	59	30	46	55
4800–9600	22	30	40	51	27	42	52

* Consult the manufacturer for data on sound regeneration due to air flow.



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

Fig. 13 . . . . Attenuation in Decibels Provided by (A) Unlined Bend, and (B) Lined Bend in a Duct with the Lateral Dimension D

Plenum Absorption

In systems where individual ducts are directed to a number of rooms, and sound treatment is required in every duct, a sound absorption plenum on the fan discharge as shown in Fig. 12 will often prove the most economical arrangement.

Based on both experiment and ray acoustics theory, the following approximate expression has been derived for acoustic plenum attenuation.[21]

$$R = 10 \log_{10} \frac{1}{\dfrac{S_e \cos\theta}{2\pi d^2} + \dfrac{1-\alpha}{\alpha S_w}} \tag{22}$$

where

- R = attenuation, decibels.
- α = absorption coefficient of the lining, dimensionless.
- S_e = plenum exit area, square feet.
- S_w = plenum wall area, square feet.
- d = distance between entrance and exit, feet.
- θ = the angle of incidence at the exit, i.e., the angle which the direction d makes with the normal to the exit opening, degrees.

For frequencies sufficiently high so that the dimensions of the plenum exceed about one wavelength, Equation 22 will predict the sound attenuation within a few decibels. At low frequencies, somewhat more attenuation is realized than will be computed by Equation 22, due to the existence of a resonant muffler action in the duct-plenum system.

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. 13 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. 13 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. 13 Part B.

Regeneration of Sound

Air flow generates sound energy in elbows, vanes, sound traps, or any other element of the duct system where turbulence may be introduced. This sound is generally broad band in character. The final sound power level is calculated first on the basis of no regeneration and then the generated sound power level is added logarithmically to it.

Branches

At a junction where a duct divides or has side branches or outlets, the sound power traveling down the duct divides.

The decibel reduction in sound power from the main duct to any branch may be calculated as 10 $\log_{10}$ of the ratio of the branch area to the total area of all branches leaving the junc-