Selection of the Absorptive Material

When a sound wave impinges on the surface of a porous material, a vibrating motion is set up within the small pores of the material by the alternating sound waves. As the ratio of the cross-sectional area of the pores to their interior surface is small, the resistance to the movement of air in the pores is large. This viscous resistance within the pores of the material converts a portion of the sound energy into heat. The decimal fraction representing the absorbed portion of the incident sound wave is called the absorption coefficient. Considerable absorption may also result, particularly in the low frequency range, from the flexural vibrations of the duct. In the selection and application of the absorptive material, the following points should be considered:

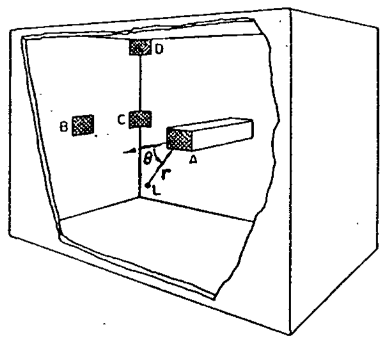

FIG. 15. FOUR TYPICAL MEANS FOR TERMINATING A VENTILATING DUCT IN A ROOM

A. Duct projecting in the room.
B. Duct in the center of and flush with the wall.
C. Duct in the center of one edge.
D. Duct in the corner.

The listener L is at distance r and angle θ from the duct opening.

1. For the absorption of the low frequencies below 500 cps the material should be 2 to 12 in. thick. Thin materials, particularly when mounted on hard solid surfaces, will absorb only the high frequencies.

2. In order to provide as much low frequency noise absorption as possible by means of flexural vibration, it is desirable to fasten the absorptive panels discontinuously. This result may be attained to some extent by spot cementing, but better results are obtained when it is possible to fasten the absorptive panels to furring strips, leaving an air space behind. However, the exact resonance characteristics of the panels, and thus their absorption, are so unpredictable that flexural vibration cannot be relied upon for a specific value of attenuation.

Requirements for a good sound absorption material are: (1) high absorption at low frequencies;[10] (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.

DETERMINATION OF ROOM LEVELS

In the previous sections on fan and grille noise, sound power levels were given in dbe referred to 10^{-13} watt. These quantities as they appear at

the duct termination (grille) must be converted to sound pressure levels in the room, because it is sound pressure to which the ear and the sound level meter respond. The sound pressure level at a distance r from the grille opening and at an angle θ with respect to an axis perpendicular to its surface is given by the equation[13]

$$L_p = \text{PWL} + 10 \log_{10} \left(\frac{Q}{4\pi r^2} + \frac{4}{R} \right) + 0.5 \text{ dbc} \qquad (24)$$

where

PWL = sound power level emitted at the duct termination and is the power summation of the attenuated fan noise and the grille noise in dbe (See *Example 3*).

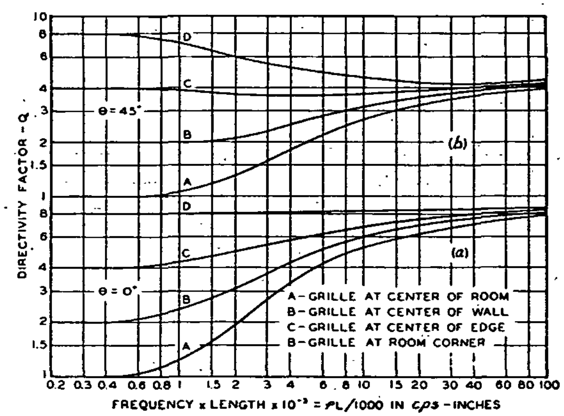

FIG. 16. DIRECTIVITY FACTOR Q FOR THE FOUR DUCT CONFIGURATIONS OF FIG. 15

A. The value of Q is given for $\theta = 0$; *i.e.*, directly in front of the duct opening.
B. Same as for (A) except the value of Q is given for $\theta = 45$ deg.
The f equency f is in cps and the duct is assumed to be square with an area L^2 in square inches.

Q = directivity factor and is a dimensionless function of θ.
r = distance from the duct opening, feet.
R = the room constant, square feet. (R increases with the amount of acoustical absorption in the room and generally depends somewhat upon frequency.)

In Fig. 15 four methods are shown for terminating a ventilating duct in a room. In each of these cases, the noise power radiates into the room. Low frequency sounds radiate equally in all directions. High frequency sounds tend to "beam" in the direction the duct opening is facing. The magnitude of this beaming effect is described mathematically by the directivity factor Q. After the sound at any frequency has reflected from a wall, it generally travels around the room many times to produce reverberant sound. This fact appears in Equation 24, wherein the first term in the parenthesis described the *direct* sound (prior to reflection) and the second term described the *reverberant* sound (the result of many reflections).

The directivity factor Q is of importance only when the listener is near the duct termination, *i.e.*, when r is small. At large distances, *i.e.*, when the first term becomes negligible compared to the second, the listener hears only the reverberant sound.