tions of the duct. In the selection and application of the absorptive material, several points should be considered.

1. For the absorption of the low frequencies the material should be at least 1 to 2 in. thick. Thin materials, particularly when mounted on hard solid surfaces, will absorb the high frequencies and reflect the low.

2. In order to take advantage of low frequency noise absorption by panel vibration, it is advisable to fasten the absorptive sheets to stripping so that the panels themselves

TABLE 5. APPROXIMATE ATTENUATION BETWEEN GRILLES AND ROOM

Outlet Velocity fpm	Air Change: Min.	Live Room[b] $a^a = 0.05$ db	Medium Room[c] $a = 0.15$ db	Dead Room[d] $a = 0.25$ db
500	5	11	16	18
	10	14	19	21
	15	16	21	23
	20	17	22	24
750	5	13	18	20
	10	16	21	23
	15	18	23	25
	20	19	24	26
1000	5	14	19	21
	10	17	22	24
	15	19	24	26
	20	20	25	28
1250	5	15	20	22
	10	18	23	25
	15	20	25	27
	20	21	26	28

[a]Average absorption coefficient for the room.

[b]Live room average absorption coefficient 0.05. Bare wood or concrete floor—hard plaster walls and ceiling—minimum of furniture.

[c]Medium room average absorption coefficient 0.15. Carpeted floor, upholstered furniture, hard plaster walls and ceiling or bare room with acoustically treated ceiling.

[d]Dead room average absorption coefficient 0.25. Heavy carpeted floor. Walls and ceiling acoustically treated. Upholstered furniture.

may vibrate. However, the exact resonance characteristics of the panels and thus their absorption is so unpredictable that panel resonance cannot be relied upon for a specific value of attenuation.

Requirements for a good sound absorption material are: (1) high absorption at low frequencies[4], (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.

With every application the use of sound absorptive material should be considered in the dual function of insulation and sound absorption. It has been shown theoretically[5] that the reduction, in decibels per linear foot,

[4]For coefficients of commercial sound absorbent materials see Bulletin *Acoustical Materials Association*, 919 No. Michigan Ave., Chicago, Ill.

[5]Sound Propagation in Ducts Lined with Absorbing Materials, by L. J. Sivian (*Journal Acoustical Society of America*, Vol. 9, p. 1937).

of sound transmitted through a duct lined with sound absorbing material is related in a rather complicated manner to the size and shape of the duct, to the frequency of the sound, and to the sound absorbing characteristics of the lining. Experimnetal evidence likewise indicates that there is no simple formula involving the variables which will apply accurately to all cases. However, it may be stated generally that the attenuation is directly proportional to the length of lined duct. It decreases as the cross sectional area increases, and increases as the aspect ratio is increased.

The noise reduction varies to a considerable extent with the frequency of the sound. In calculating noise reduction, consideration should be given both to the comparative efficiency of the duct lining material at different frequencies, and to the frequency distribution of the noise to be

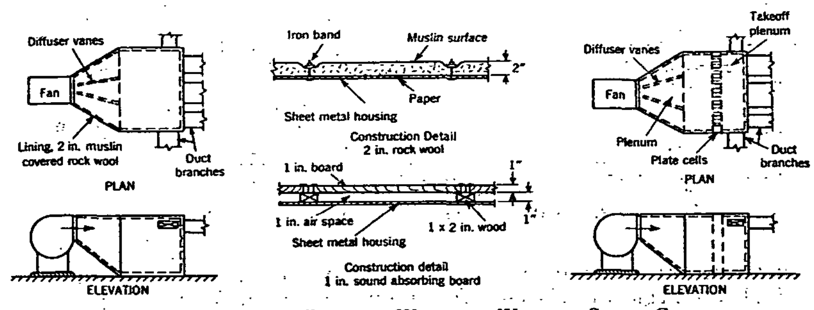

FIG. 1. ABSORPTION PLENUMS WITH AND WITHOUT SOUND CELLS

quieted. In the case of fan noise, it is recommended that calculations be based on the frequency 256 cycles, since most of the noise energy is in the region of this frequency. In quieting noise due to air turbulence and eddy currents, in which the high frequencies predominate, the frequency 1024 cycles should be used.

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. 1, will often prove the most economical arrangement. The absorption in the plenum may be approximated by Equation 4.

$$db \text{ (Attenuation)} = 10 \log_{10} \frac{\text{Plenum Absorption in Sabines}}{\text{Area Fan Discharge}} \quad (4)$$

The area of the plenum should be at least ten times as great as the fan discharge area. The plenum should be lined with 2 in. of muslin covered rock wool blanket or 1 in. sound absorbing board preferably nailed to wood strips on the inside of the plenum. With such a lining the plenum is particularly effective in reducing low frequency fan noise. The absorption of the plenum in sabines is the sum of the products of each interior