TABLE 5. ATTENUATION OF ELBOWS[a]

ELBOW	SIZE IN.[b]	ATTENUATION PER ELBOW, db
Very small	2 wide	3
Small	3 to 15	2
Medium	15 to 36	1.5
Large	36 plus	1

[a] The attenuation in vaned elbows should be considered the same as in elbows having the same dimensions as the radius of curvature of the vanes. If the vanes are lined for the purpose of damping any vibrations in them, one third may be added to the attenuation values listed.

[b] These attenuation values are based on elbows having a center line radius 1.5 to 2 times the diameter or width of the duct. The attenuation will be greater if the ratio is less than 1.5 and less when the ratio is greater than 2.

This attenuation is a function of the total grille area (supply and return) and the total sound absorption of the room in *sabins*. (The sound absorption of a room in *sabins* is the summation of the products of each surface of the room measured in square feet multiplied by its corresponding absorption coefficient. The *sabin* is a unit of sound absorption equivalent to the absorption of one square foot of a totally sound-absorbent surface). The attenuation is given in Equation 5 as:

$$db\left(\begin{matrix}\text{Attenuation between}\\ \text{grilles and room}\end{matrix}\right) = 10 \log_{10} \frac{\text{Total Room Absorption in Sabins}}{\text{Total Grille Area}} \quad (5)$$

Values in Table 7 approximate the attenuation for various rates of air change, and general types of room surfaces.

DUCT SOUND ABSORBERS

The difference between the required sound attenuation and the natural attenuation must be supplied by the proper sound treatment of the ducts.

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:

TABLE 6. ATTENUATION AT DUCT BRANCHES OR OUTLETS

RATIO $\frac{\text{BRANCH DUCT + OUTLET AREA}}{\text{SUPPLY DUCT AREA}}$ OR $\frac{\text{SUM OF BRANCH AREAS}}{\text{SUPPLY DUCT AREA}}$	ATTENUATION PER TRANSFORMATION, db
1.00	0.0
1.20	0.8
1.35	1.3
1.50	1.8
1.75	2.5
2.00	3.0

1. For the absorption of the low frequencies below 500 cycles per second 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 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;[5] (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.

TABLE 7. 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 ciling acoustically treated. Upholstered furniture.

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[6] that the reduction (in decibels per linear foot) 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. Experimental 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 in decibels at a given frequency is directly proportional to the length of