One series of experiments[6] made on a commonly used type of duct lining material (1 in. rock wool sheet) has shown that, subject to certain restrictions, the reduction of single-frequency sounds may be expressed by the approximate Equation 2.

$$R = 12.6\, L \frac{P}{A}\, a^{1.4} \qquad (2)$$

where

R = reduction, in decibels.
L = length of lined duct, feet.
P = perimeter of duct, inches.
A = cross sectional area of duct, square inches.
a = absorption coefficient of lining.

This formula is accurate within plus or minus 10 per cent for duct sizes ranging from 9 x 9 in. to 18 x 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. In Table 2, the absorption coefficients at different frequencies of a material of the above mentioned type are listed, together with the corresponding values of Equation 2.

TABLE 2. DECIBEL REDUCTION FORMULAE FOR TYPICAL DUCT LINING MATERIAL

FREQUENCY	ABSORPTION COEFFICIENT	REDUCTION, DB
256	0.37	3.0 L P/A
512	0.69	7.5 L P/A
1024	0.78	9.5 L P/A
2048	0.78	9.5 L P/A

Results of other experiments indicate, however, that Equation 2 may be in error when applied to other types of duct lining material and to duct sizes and shapes outside of the range specified. An empirically derived chart[7] representing the average experimental data on a number of different types of materials including the rock wool sheet mentioned as applicable to Equation 2 is shown in Fig. 1. Since individual materials vary somewhat, the curves in Fig. 1 are only given as representing the best available averages for duct sizes of square cross-sections from 6 x 6 in. to 48 x 48 in. As an illustration, the dotted lines in the chart show values calculated from Equation 2 which indicate that the slope for this particular material is somewhat different than from the average curves. The curves in Fig. 1, as well as Equation 2, show that the reduction in decibels is directly proportional to the length of duct lined, and that the larger the duct the greater will be the length which must be lined in order to obtain a given noise reduction.

From Table 2 it will be noted that the noise reduction varies to a considerable extent with the frequency of the sound. In calculating noise reduction, therefore, consideration should be given both to the comparative efficiency of the duct lining material at different frequencies,

[6]The Absorption of Noise in Ventilating Ducts, by Hale J. Sabine (*Journal Acoustical Society of America*, Vol. 12, p. 53, 1940).

[7]The Prediction of Noise Levels from Mechanical Equipment, by J. S. Parkinson (*Heating and Ventilating*, March, 1939, pp. 23-26).

and to the frequency distribution of the noise to be 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.

It should be noted that the lining should be installed at or near the outlet, in order to reduce effectively all sounds which may be generated in the system up to this point. The installation of lining near the outlets rather than near the fan is also more economical, because a greater noise reduction per square foot of lining material can be obtained in the smaller ducts leading to the outlets.

Estimating Required Noise Reductions

The amount of noise reduction which is required in any given case will depend both on the noise level in the room with the ventilating equip-

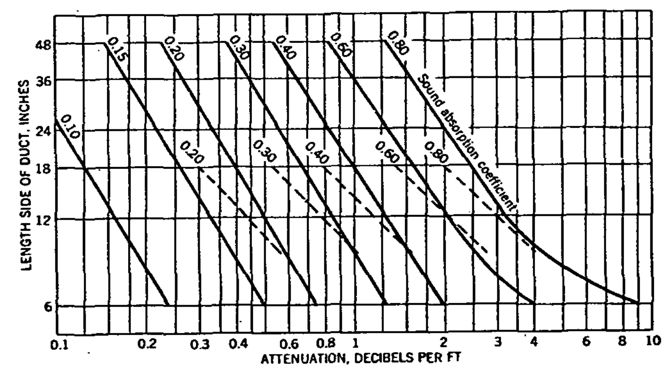

FIG. 1. SOUND ATTENUATION FOR VARIOUS ABSORBING DUCT LINERS

ment shut off, and on the noise level set up in the room by the equipment. Since in most cases it is difficult or impossible to determine these levels accurately, it is best to estimate the required noise reduction on the basis of experience and to allow a liberal safety factor. A guide for this purpose is shown in Table 3, which applies to fan noise. Attention is specifically called to its empirical nature and to the necessity of exercising judgment in applying it. When properly used with Table 1 the values in Table 3 provide a solution which may be both useful and simple. It is important to understand that the reductions referred to in this chart are based on the *average* noise levels set up in the room by the ventilating or air conditioning equipment. In the case of a piece of equipment which generates a noise level of 95 db, when the noise is measured immediately next to the machine, there might be a reduction of 15 db in passing through the duct, and a further difference of 15 db[8] between the noise at the outlet supply

[8]The drop between the level at the grille and the average level in the room will be governed by the absorbing power of the room. This is expressed in sabines and is equal to $\Sigma\, a\, s$ where a is the absorption coefficient of the surface and s the area of that surface. The total absorbing power of the room is thus the summation of the absorbing power of the various room surfaces. For a discussion of the effect of the room absorption see Loc. Cit. Note 7.