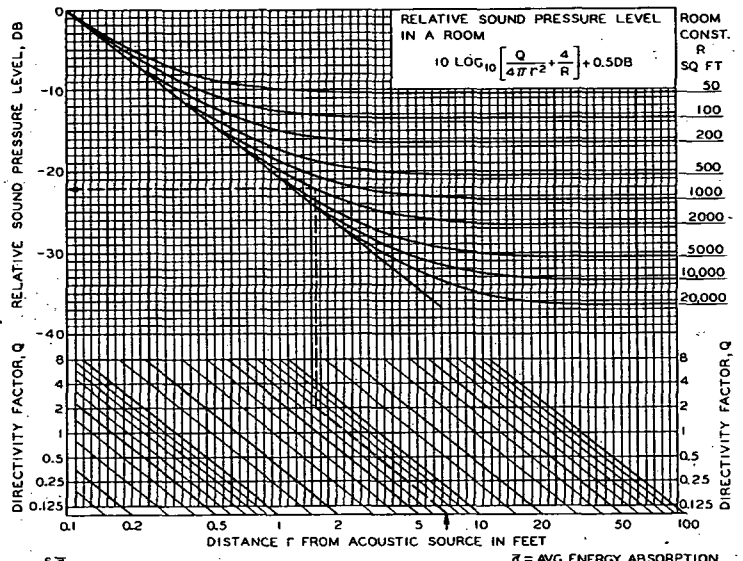

The listener's position is at a distance r and an angle θ with respect to the duct opening. Q is determined from θ and from the duct dimensions (see Fig. 18). To use the graph proceed as for the example shown by the dotted line for r = 7 ft, Q = 2, and R = 2000 sq ft. The sound pressure level in the room equals the sum of the ordinate and the sound power level. Normal room temperature and pressure conditions are assumed.

Fig. 20 .... Curves for Determining the Sound Pressure Level in the Room Relative to the Sound Power Level

system, the total acoustic power delivered to the room by the fan will be 108 dbe. Assuming that the branch fittings at *D*, *E*, and *F* are similar to that at *C* in Fig. 21, the unattenuated fan acoustic power delivered to each of the four 12 x 18 in. grilles will be approximately

$$PWL_{(duct\ DB)} = 108 - 10 \log 4 = 102 \text{ dbe}$$

The octave band spectrum of the centrifugal fan noise is given by Fig. 6. This chart indicates that the power level in the first band (20–75 cps) will be about 102-1 or 101 dbe, and the power level in each succeedingly higher octave band will be 5 dbe less. These levels are entered in line 1 of the calculation Table 9.

The next step is to determine the natural duct attenuation between the fan discharge and the room supply grilles. From Table 4 the attenuation for straight sheet-metal ducts of *medium size* is 0.05 db per ft at all frequencies. Let us assume that all of the ducts of this system fall within this medium category. The total length of the duct run from Station *A* to Station *H*, Fig. 21, is 90 ft. The straight duct attenuation is, therefore, 0.05 (90) = 5 db, which is entered in line 2 of Table 9. It should be noted here that the ducts *CD* and *DH* of 12 x 48 and 12 x 15 in. dimensions, respectively, are of about the same size as those reported in Table 5. Hence if we assume the attenuation for these two *bare* ventilation ducts can be taken from Table 5, it will be found that the straight duct attenuation between *C* and *H* (35 ft) will be approximately 10 db in the lowest two octave bands, 6 db in the third band, and 3 db for all octave bands above 300 cps. That is, using Table 5 for ducts *CD* and *DH*, and Table 4 for ducts *AB* and *BC*, the first three columns in line 2, Table 9, would read 12, 12, and 9 db in that order, and the other columns would be unchanged at 5 db. It would appear, therefore, that the 5 db attenuation values for the lower three octave bands are probably overly conservative. The divided-flow fitting at *B* may be considered equivalent in attenuation to an 18-in. square bend. Values are read from Fig. 10, Part A and entered as line 3 in the calculation table. The rounded corners of the branch flow fittings at *C*, *D*, *E*, *F*, and *G* are assumed to have no attenuation. The 12 x 15 in. risers serving each of the wall grilles have a square bend (see Fig. 22), and attenuation values are read from Fig. 10, Part A and entered as line 4 of Table 9. The attenuation due to the end reflection loss at the grille face is given by Fig. 11. For the 12 x 18 in. grilles used here $L = \sqrt{12 \times 18} = 14.7$ in. Thus, for the first octave band (20–75 cps), which has a geometric mean frequency of 40 cps, $fL/1000 = (40 \times 14.7)/1000 = 0.58$ and the end loss is 13 db.

The attenuation in the other octave bands is similarly determined and entered in line 5 of Table 9. The total natural duct attenuation is now found by summing lines 2, 3, 4, and 5 of Table 9, and the result appears in line 6. This total attenuation may now be subtracted from the unattenuated power level in line 1 to give the estimated acoustic power level radiated into the room from the outlet grille at Station *H*. Line 7 of Table 9 gives the result.

Table 9 .... Summary of Calculations for *Example 3* on Ventilating Noise Levels in Libary Reading Room

Item	Octave Frequency Bands 20–75 cps	75–150 cps	150–300 cps	300–600 cps	600–1200 cps	1200–2400 cps	2400–4800 cps	4800–10,000 cps
1. $PWL_{(duct\ DB)}$	101	96	91	86	81	76	71	66
2. $Attenuation_{(st.\ duct)}$	5	5	5	5	5	5	5	5
3. $Attenuation_{(bend\ B)}$	—	—	2	7	7	6	11	12
4. $Attenuation_{(bend\ H)}$	—	—	1	4	7	7	8	10
5. $Attenuation_{(end\ loss)}$	13	7	4	1	—	—	—	—
6. Total duct attenuation	18	12	12	17	19	18	24	27
7. $PWL_{(grille\ outlet)}$	83	84	79	69	62	58	47	39
8. $fL/1000$ cps-in	0.5	1.3	2.5	5.1	10.2	20.4	40.8	81.6
9. Q	2	2	2.2	2.7	3.2	3.6	3.9	4.1
10. Rel. L_p at 7 ft	−22	−22	−22	−21	−20	−20	−20	−20
11. L_p at 7 ft	61	62	57	48	42	38	27	19
12. $PWL_{(all\ grilles)}$	89	90	85	75	71	67	56	48
13. Rel. L_p far field	−26	−26	−26	−26	−26	−26	−26	−26
14. Reverberant L_p	63	64	59	49	45	41	30	22
15. Criterion L_p	60	51	43	37	32	30	28	27
16. Required attenuation	3	13	16	12	13	11	2	—
17. Attenuation 4 ft pkg. unit	7	11	14	30	40	40	38	33

Determining Room Sound Pressure Levels

The next step, then, is to calculate the sound pressure level at the position in the room occupied by the listener nearest to any one grille, and for the overall reverberant sound pressure level in the room due to the sound power radiated from all of the grilles. Fig. 22 shows that the position of the nearest listener is 7 ft from the grille. To determine L_p at this position, determine the directivity factor *Q* at 45 deg to the grille face; this is found from Fig. 18. The parameter $fL/1000$ is determined by taking the characteristic length *L* as the shortest side of the grille face or 12 in. Thus, for the first octave band, $fL/1000 = 40\ (12)/1000 = 0.48$. This value together with all the corresponding values for the other seven octave bands are entered in line 8 of Table 9. Line 9 of the table gives the corresponding directivity factors as read from Fig. 18, using curve *B* since the grille is flush with the wall but not at an edge or corner.

It was initially assumed that the library reading room had average acoustical properties, and consequently, the room constant *R* in sq ft may be read from the line marked *average room*

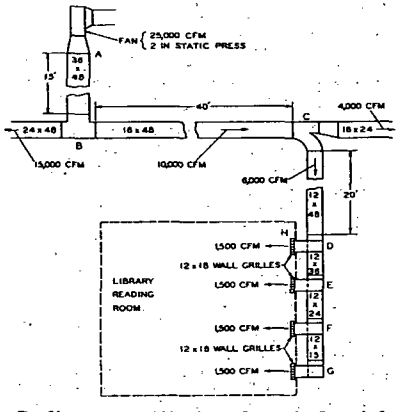

Fig. 21 .... Assumed Ventilating System for Example 3

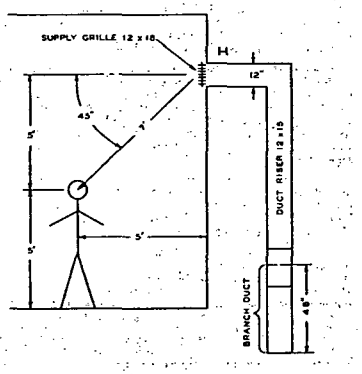

Fig. 22 .... Location of Nearest Listener to a Supply Grille