power level to yield the sound pressure level at the distance r and the angle θ in the room (See Equation 24).

It is seen from Fig. 18 that the noise from a ventilating duct is less at distances far from it than nearby. Moreover, at large distances, the levels produced in the room depend only on the power level of the source and the room constant and not on the directivity factor and the distance r.

Example 3: To illustrate the application of the noise criteria and control procedures outlined in this chapter, calculation will be made for the required treatment for the ventilation system supplying the library reading room of Fig. 19. This room has a total volume of 80,000 cu ft and may be considered as an *average room* for acoustic properties (see Fig. 17). The total air supply to the reading room is 6000 cfm which

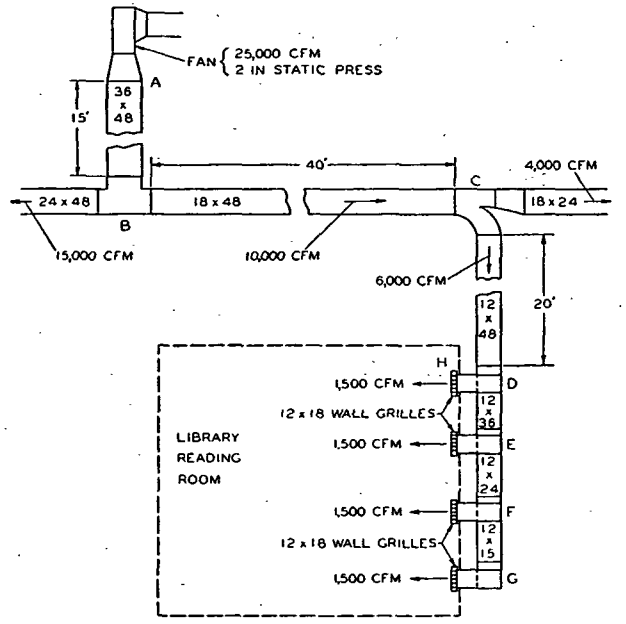


FIG. 19. ASSUMED VENTILATING SYSTEM FOR *EXAMPLE 3*

is equally divided between four 12 × 18 in. supply grilles located along one wall. The supply of outdoor air is from a central fan system which handles a total of 25,000 cfm at 2 in. water static pressure and requires a 15 hp motor.

Solution: It is necessary to determine the noise level in the reading room as a result of the ventilating system, both for the position of the nearest listener to a grille, and for a position remote from the supply grilles since it is impossible to tell beforehand which will be greater. The required attenuation for acceptable octave band noise levels will then be determined.

Analysis of Fan and Duct System

The acoustic power level of the fan should be computed from Equation 18 when the specific power level is available. In this example it is assumed that the specific sound power level is not known. Therefore, employ the approximate Equations 19 or 20. From Equation 19:

$$\text{PWL}_{(\text{duct AB})} = 100 + 10 \log 15 + 10 \log 2 = 114.7 \text{ dbe}$$

TABLE 7. SUMMARY OF CALCULATIONS FOR *EXAMPLE 3* ON VENTILATING NOISE LEVELS IN LIBRARY 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. $\text{PWL}_{(\text{duct DH})}$	101	96	91	86	81	76	71	66
2. $\text{Att'n}_{(\text{st. duct})}$	5	5	5	5	5	5	5	5
3. $\text{Att'n}_{(\text{bend B})}$	—	—	2	7	7	6	11	12
4. $\text{Att'n}_{(\text{bend H})}$	—	—	1	4	7	7	8	10
5. $\text{Att'n}_{(\text{end loss})}$	13	7	4	1	—	—	—	—
6. Total duct att'n	18	12	12	17	19	18	24	27
7. $\text{PWL}_{(\text{grille outlet})}$	83	84	79	69	62	58	47	39
8. fL_f/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. $\text{PWL}_{(\text{all grilles})}$	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 Att'n	3	13	16	12	13	11	2	—
17. Att'n 4 ft pkg. unit	7	11	14	30	40	40	38	33

or from Equation 20:

$$\text{PWL}_{(\text{duct AB})} = 65 + 10 \log 25{,}000 + 20 \log 2 = 115 \text{ dbe}$$

which agreement is better than the accuracy expected from these equations.

Of this total acoustic power generated by the fan the main interest is in the part that reaches the reading room. At each duct branch the power will divide approximately as the ratio of the branch duct area to the total duct area after the branch. Thus at station B (Fig. 19) the acoustic power delivered to the 18 × 48-in. duct, neglecting any attenuation in the system, will be

$$\text{PWL}_{(\text{duct BC})} = \text{PWL}_{(\text{duct AB})} + 10 \log (A_{\text{branch}}/A_{\text{total}})$$

$$= 115 + 10 \log \left[\frac{18 \times 48}{(24 \times 48) + (18 \times 48)} \right] = 111 \text{ dbe}$$

At station C the power division gives

$$\text{PWL}_{(\text{duct CD})} = 111 + 10 \log \left[\frac{12 \times 48}{(18 \times 24) + (12 \times 48)} \right] = 108 \text{ dbe}$$

Thus neglecting, at first, the attenuation in the connecting duct 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. 19, the unattenuated fan acoustic power delivered to each of the four 12 × 18-in. grilles will be approximately

$$\text{PWL}_{(\text{duct DH})} = 108 - 10 \log 4 = 102 \text{ dbe}$$

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 7.

The next step is to determine the natural duct attenuation between the fan discharge and the room supply grilles. From Table 3 the attenuation for straight sheet