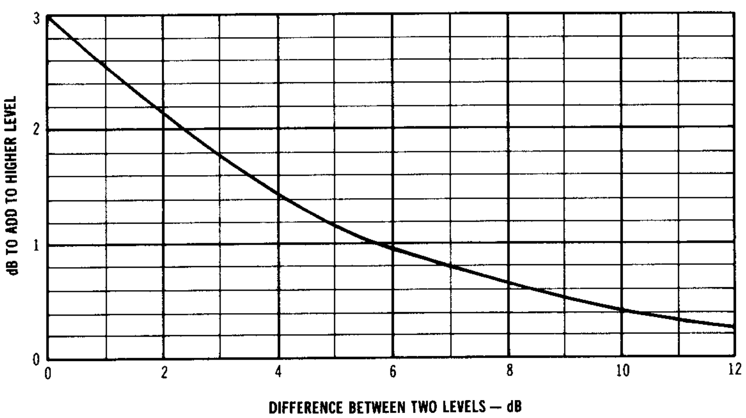

Figure 1-17 Graph used for combining decibels.

bination will be increased by 0.5 dB or less. If the noise of a fan being measured is only 10 dB above background noise, 0.5 dB should be subtracted from the combined reading.

This procedure for combining levels is based on random-type sounds. If two coherent periodic waves are combined, the combined level will be 6 dB higher, not 3 dB.

An example of combining two coherent periodic waves has already been given in Fig. 1-11A and the associated discussion.

1.17.4 Spectrum Level and the Decibel

Spectrum level is the sound pressure level of a sound with a bandwidth of 1 Hz. It is a necessary concept in comparing spectra measured with analyzers of different bandwidths. There is no constant bandwidth sound analyzer that measures spectrum level directly. Instead, we have analyzers of finite constant bandwidth such as 1%, 3%, 10%, one-third octave, octave, or other constant percentage bandwidths. The spectrum level can be obtained from any band level by the following operation:

$$\textit{spectrum level} = \textit{band level} - 10\log(f_2 - f_1) \qquad (1\text{-}22)$$

where,

$(f_2 - f_1)$ is the width of the band giving the band level reading.

For example, an octave band centered on 1 kHz accepts energy from 707 to 1414 Hz or a bandwidth of 707 Hz. If the sound pressure level of a sound in this band is 76 dB, the spectrum level is

$$\begin{aligned}\textit{spectrum level} &= 76\,dB - 10\log 707\\ &= 76\,dB - 28.5\,dB\\ &= 47.5\,dB\end{aligned}$$

If the same sound is measured with a one-third octave analyzer centered on 1 kHz, the band sound pressure level would be 71.2 dB for the overall band. To compare this with the octave band spectrum level, 71.2 dB − 10 log 232 = 47.5 dB. The results of measurements by filters of different widths can thus be compared on a spectrum-level basis. Table 1-3 lists correction factors at 1 kHz by which measurements of the same sound by analyzers of five different bandwidths may be compared.

The previous discussion assumes that the sound being measured is continuously distributed throughout the range of interest and that the total level is the result of the addition of powers of components of different frequencies (i.e., that the meter had true rms characteristics).

This 1-Hz bandwidth is also of interest in masking. For example, a tone of a given level is just audible when the

Table 1-3 Spectrum Levels From Filters of Different Bandwidths

Analyzar Type	Bandwidth at 1000 Hz	Correction Factor 10 Log (Bandwidth)
1/1 Octave	707 Hz	28.5 dB
1/3 Octave	232	23.7
10%	100	20.0
3%	30	14.8
1%	10	10.0

spectrum level of the noise just masking it is approximately equal to that of the tone.

Overall band levels can be readily calculated from narrower band levels by adding powers.

1.18 MATHEMATICS OF THE OCTAVE

An octave is any 2:1 ratio of frequencies, which is as true in going from 10 Hz to 20 Hz as it is going from 10,000 to 20,000 Hz. The mathematical expression of the octave is:

$$\frac{f_H}{f_L} = 2^N \qquad (1\text{-}23)$$

where,

f_H is the high frequency edge of the octave interval in Hz,

f_L is the low frequency edge of the octave interval in Hz,

N is the number of octaves.

For example, how many octaves are in the 20-Hz to 20-kHz range?

$$2^n = \frac{f_H}{f_L}$$

$$= \frac{20{,}000}{20}$$

$$= 1000\,Hz$$

taking logs of both sides,

$$N \log 2 = \log 1000$$

$$N = \frac{\log 1000}{\log 2}$$

$$= \frac{3}{0.3010}$$

$$= 9.966$$

Question: What upper frequency would make an even ten octaves above 20 Hz?

$$\frac{f_H}{f_L} = 2^N$$

$$\frac{f_H}{20\,Hz} = 2^{10}$$

$$f_H = 20\,Hz \times 2^{10}$$

$$= 20{,}480\,Hz$$

Question: If 880 Hz is the lower edge, what frequency is one octave higher?

$$\frac{f_H}{f_L} = 2^N$$

$$\frac{f_H}{880} = 2^1$$

$$f_H = 2 \times 880$$

$$= 1760\,Hz$$

Better Question: What is the upper edge of a one third octave bandwidth centered on 1000 Hz? The f1 = 1000 Hz but the upper edge would be one sixth octave higher than the one third octave, so N = 1/6.

$$\frac{f_H}{1000} = 2^{\frac{1}{6}}$$

$$F_H = 1000 \times 2^{\frac{1}{6}}$$

$$= 1122.5\,Hz$$

The lower edge of the one-third octave centered on 1000 Hz is

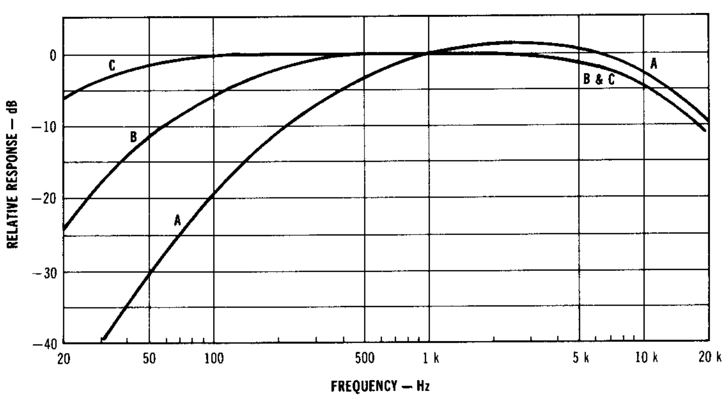

Figure 1-18 The frequency response of three standard sound level meter networks (A, B, and C).