Table 3. Average Sound Conditions in Various Types of Rooms and Buildings[a]

Flat Response Network

Type of Room or Building	Decibels
Broadcasting studios	20–30 (very quiet)
Residences, churches, libraries, apartments, auditoriums, executive offices, class rooms	40–55 (quiet)
Hospitals, court rooms, quiet offices, show rooms, small retail stores, tea rooms, hotel dining rooms, foyers, upper floors of department stores, recreation rooms	45–60 (moderately quiet)
Banking rooms, beauty salons, barber shops, general offices, restaurants, main floors of department stores, cocktail lounges, dairy bars, tap rooms, billiard halls	55–70 (average)
Gymnasiums, transportation waiting rooms, drug stores, grocery stores, cafeterias, super markets, recreation halls, post offices, swimming pools, locker rooms, garages, service stations, dance halls, laundries, dry cleaners, bowling alleys	65–80 (moderately noisy)
Warehouses, office machinery, field houses, hangars, skating rinks, loading platforms, packing plants, factories, machine shops, foundries, forge shops, round houses, steel mills	75–100 (noisy)

[a] Values based on recent surveys.

tion equipment out of operation, unless such equipment presented no acoustical addition to normal conditions. The windows and doors were closed to simulate the conditions of normal occupancy. In Table 2, minimum, representative and maximum levels are given for each type of space, classified as shown in the following paragraph. In Table 3, the minimum to maximum range is shown, with the same general classification.

Minimum sound level refers to spaces within well-constructed buildings, typified by double windows, carpeted floors, and acoustically-treated walls and ceilings. In such spaces heavy upholstered furniture is also usually used.

Representative sound level refers to spaces within average construction with average furnishings, and exposed to external sounds typical of the locality in which the space is usually found.

Maximum sound level refers to (1) any space within inexpensive construction where bare furnishings are used, and where noise is normally not an important factor, or (2) spaces in close proximity to very intense street traffic or industrial noise.

In general, if the sound level in the space resulting from the operation of the air conditioning equipment only, is equivalent to, or less than, the typical level (from Tables 2 or 3 or, better still, determined by actual site measurement) the installation will prove satisfactory. If the space level and the equipment level are equal and heard together, the resultant level will be 3 db higher than either space or equipment level alone. However, to minimize possible annoyance due to introduction of single or distinctive frequency components from the equipment, it is desirable to design for an equipment sound level of at least 5 db below the typical space level.

NOISE GENERATED BY FANS

Noise generated by fan wheels may be divided into two classifications, rotational noise and vortex noise. The rotational noise may be described

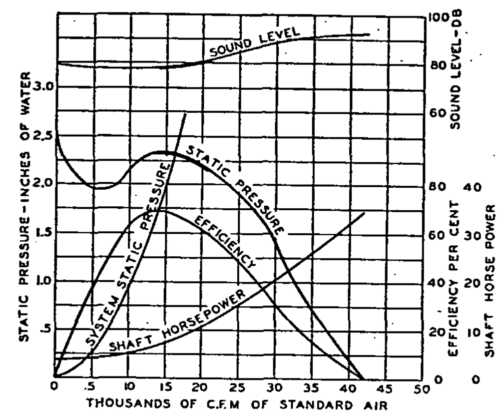

Fig. 1. Sound Level Characteristics of Typical Centrifugal, Multi-Blade Ventilating Fan

as that due to the thrust and torque applied to the air. Vortex noise is that due to the shedding of vortices from the blade, and is dependent on the angle of attack, velocity, air turbulence, and blade shape. Vortex noise is due to pressure variations on the blade as a result of variations of air circulation. Given the noise level at the outlet or inlet of one type of fan construction under specific conditions of size, tip speed, and total pressure, the noise levels at other values of tip speed, total pressure, and size may be approximated by the relationships:

1. For constant size and point of rating, the noise level of a fan will increase with increasing speed.

$$db\text{ (change)} = 50 \log_{10}\left(\frac{RPM_2}{RPM_1}\right) \quad (3)$$

2. For constant pressure and tip speed, the noise level of a given type of fan will increase with increasing fan size.

$$db\text{ (change)} = 20 \log_{10}\left(\frac{\text{Size}_2}{\text{Size}_1}\right) \quad (4)$$

Fan size refers to wheel diameter, housing height or some dimension that is directly proportional to linear units. Fan sizes based on arbitrary systems or systems of preferred numbers, have no significance.

The noise of a given fan is not constant at constant speed if the air delivery changes due to change of resistance. In general, a backward curved blade fan is lowest in noise at or near the point of maximum efficiency; a forward curved blade fan at or between the point of maximum efficiency and shut-off; an axial flow fan at or between the point of maximum efficiency and free delivery. The noise level of a double width fan may be taken as 3 db higher than for a similar single width fan operating under the same conditions of speed and pressure.

The sound level characteristic curve of a typical ventilating fan of the centrifugal multi-blade type is shown in Fig. 1. The accented portion of the curves denotes the range of minimum sound emission. The selection and application of the fan should be made within such good application range where quietness of operation is of major consideration. The various types of fans available possess individual sound level characteristics throughout their range of possible operation. Recourse to standard