preciable velocity has not yet been mastered, although it is a subject of current investigation. Development tests indicate that the sound level at the fan outlet is in the order of 10 to 15 db higher than the average value determined by the seven-station traverse around the fan. Where sound treatment of a distribution duct is required, the initial level should be taken as approximately 12 decibels higher than the reported Code rating sound level.

KINDS OF NOISE

In solving a sound problem, it is desirable to consider, separately, the several means by which noise reaches the room. This avoids to some extent the necessity of knowing the noise level at the source, and instead, places the emphasis on ascertaining the level at the point where the sound enters the room.

The noise introduced into a room or building by ventilating or air conditioning equipment may be divided into two general kinds, depending on how it reaches the room:

1. Noise transmitted through the ducts.
   a. From equipment such as fans, motors, pumps, sprays, etc.
   b. From outside, and transmitted through duct walls into air stream.
   c. From duct wall vibrations, transmitted into air stream.
   d. From air currents, including eddying noises.
   e. Cross talk and cross noises between rooms connected by the same duct system.
   f. Noise produced by the grilles.
2. Noise transmitted through the building construction.
   a. From machine mountings as vibration.
   b. From equipment through room wall surfaces.

The next step in the solution of this problem is to present data and discuss methods whereby solutions of the noise problem can be obtained when the allowable room noise level, and the path through which the noise reaches the room, are known.

NOISE TRANSMITTED BY AIR THROUGH DUCTS

Operation of an air distribution system results in the generation of noise which may be transmitted by air through the ducts to the ventilated or conditioned room. The transmission of this noise may be controlled by the proper application of sound absorptive material within the ducts. The application of the absorptive material is a problem in balancing the room noise level requirements against the intensity of the noise generated. The four steps in the problem are:

1. Determination of acceptable room noise level resulting from the operation of the equipment.
2. Determination of noise level generated by the equipment.

Add 5 decibels to the difference between items 1 and 2 to obtain the overall noise reduction required between the equipment and the room. In the discussion which follows, reduction of noise will be referred to as *attenuation* of noise.

3. Determination of the natural attenuation of the duct system.
4. Selection of the proper sound treatment for the duct system.

The difference in decibels between the overall attenuation required and the natural attenuation (3) is the additional sound attenuation to be provided by absorptive materials installed in the duct system, or by special constructions designed to absorb sound. Experience has shown, for example, that where ventilating requirements permit, introduction of an expansion chamber or a change in area in the duct will frequently provide further reduction in low frequency noise.

Table 2. Typical Sound Levels[a]

Rooms	Sound Level in Decibels to be Anticipated: Min.	Representative	Max.
Sound Film Studios	10	14	20
Radio Broadcasting Studios	10	14	20
Planetarium	15	20	25
Residence, Apartments, etc.	33	40	48
Theaters, Legitimate	25	30	35
Theaters, Motion Picture	30	35	40
Auditoriums, Concert Halls, etc.	25	30	40
Churches	25	30	35
Executive Offices, Acoustically Treated Private Offices	30	38	45
Private Offices, Acoustically Untreated	35	43	50
General Offices	50	60	70
Hospitals	25	40	55
Class Rooms	30	35	45
Libraries, Museums, Art Galleries	30	40	45
Public Buildings, Post Offices, etc.	45	55	60
Court Rooms	30	35	45
Small Stores	40	50	60
Upper Floors Department Stores	40	50	55
Stores, General, Including Main Floor Dept. Stores	50	60	70
Hotel Dining Rooms	40	50	60
Restaurants and Cafeterias	50	60	70
Banking Rooms	50	55	60
Factories	65	77	90
Office Machine Rooms	60	70	80
Vehicles			
Railroad Coach	60[b]	70	80
Pullman Car	55[b]	65	75
Automobile	50	65	80
Vehicular Tunnel	75	85	95
Airplane	75	80	90

[a]These values are tentative. More detailed measuremeets by D. F. Seacord, Bell Telephone Laboratories (*Journal Acoustical Society of America*, Vol. 12, pp. 183-187, 1940) give average values and standard deviations of room noise in residences, offices, stores, factories, etc., in large American cities.
[b]For train standing in station, a level of about 45 db is the maximum which can ordinarily be tolerated.

DESIGN ROOM NOISE LEVEL

Measurements of sound levels in various types of rooms and locations have been observed by numerous investigators. However, close agreement upon these values has not been realized, and more detailed measurements are needed to accurately establish the normal sound levels in occupied spaces and enclosures subject to sound analysis and control. Typical sound levels, of a tentative nature, based upon earlier determinations, are listed in Table 2. The levels listed are weighted levels by the 40 db or 70 db network, depending upon the range of level existing. Levels taken upon the flat response network may be from 5 db to 20 db higher, as governed by the predominating frequencies which may influence the weighting level.

Table 3 lists sound levels based upon more recent surveys than Table 2, and upon the basis of the flat response network. The flat response network offers a more logical correlation of space sound level to fan sound level which, under present practice, is reported upon basis of the *flat response* reading.

The values listed were determined with the air conditioning or ventila-