SOUNDPROOFING IN BUILDINGS

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The demand for quiet rooms in hospitals, hotels, and office buildings, the desirability of insulating music studios and other rooms where disturbing sounds are produced, have led to repeated requests from architects and builders for reliable information on effective methods for insulating sound. Although present knowledge of the subject is incomplete, nevertheless, on account of the pressing need for guidance in such matters, it is thought desirable to collect and present the available information in a systematic way, giving the methods and results of various investigations relating to the action of materials on sound, describing practical installations of soundproofing, and setting forth in accordance with existing knowledge recommendations that may be applied where sound insulation is wanted.

This introductory statement in a recent bulletin* on "Soundproof Partitions" indicates the lack of information on the subject of soundproofing.

The action of sound in a building is much of a mystery to many people. There is a popular belief that wires stretched in an auditorium will be of benefit for faulty acoustics, or, if this fails, that a sounding board over the speaker's head will remedy matters. Also, concerning sound proofing in buildings, an impression prevails that an effective wall is one containing air spaces. These popular conceptions are not altogether supported by the facts. People who regard the problems with a degree of seriousness realize that the action of sound is not a matter of chance, but that the phenomena must accord with scientific laws.

In the bulletin mentioned, the results are given of a survey of the subject of sound insulation in buildings from three standpoints,—the theory of the subject, experimental investigations, and practical installations of soundproofing. This information thus collected, while

* "Sound-Proof Partitions" Bulletin 127, University of Illinois Engineering Experiment Station.

drawn from different sources and apparently unrelated, proved quite concordant and led to conclusions concerning effective sound insulation.

Two Types of Sound in Buildings.—Two types of sound should be considered in the problem of insulation in buildings. One type includes sounds that are generated in the air and that progress through the air to the boundaries of the room; the other is composed of compressions generated in the building structure by motors, elevators, and street traffic.

Insulation of Sounds in Air.—Sounds of moderate intensity such as those generated by the human voice or a violin may be stopped with comparative ease if the walls of the room are continuous and fairly rigid. The more vigorous sounds of a cornet, trombone, etc., would require especially heavy walls or else double partitions. Any breaks in the walls for ventilators, pipes, or doors should be guarded by effective insulation.

Insulation of Building Vibrations.—Compressional waves generated in the building structure pass readily along the continuity of solid materials, and, as they have more paths for escape, are more difficult to insulate than sounds in air. Moreover, they may create trouble when they cause a wall or floor to vibrate. The insulation is based on the same procedure as that used for air sounds; namely, to interpose a new medium differing in elasticity and density. An air space in masonry would be effective if not bridged over by solid material, but since this is impossible for ordinary building constructions as the weight of bodies necessitates contact for support, an approximate insulation is sought by using air-filled substances like dry sand, ground cork, hairfelt, or flax, that possess but little rigidity but are capable of sustaining a floor or a partition that is not too heavy.

Transmission of Sound.—Sound waves in air may be transmitted through an obstructing medium in three ways. First, they may pass through the air spaces of a porous material. Second, they may be transmitted by modified waves in the new medium. In this process sound compressions and rarefactions progress rapidly

through the air, moving the molecules successively as they pass in somewhat the same way as a gust of wind blows the separate stalks in a wheat field. On reaching a solid partition the forward motion is hindered, particularly if the molecules of the new material are massive and resist compression. In this case most of the energy is reflected and only a small proportion progresses through the wall. On meeting a further discontinuity of material, such as wood or air, the waves are again affected, until finally a part of the energy emerges. Third, sound may be transmitted by setting a partition as a whole in vibration. The partition then acts as an independent source of waves, setting up compressions and rarefactions on the farther side and giving a sort of fictitious transmission. If the partition is rigid and massive the vibrations are small and very little sound is transmitted; if the partition is thin and flexible a considerable amount of energy is transferred.* Usually in building constructions the partitions are complex, as for example plaster on wood lath and studding. In this case the plaster areas between the studding act in a manner similar to drum heads and transmit sound. Hard plaster on wire lath presents a different surface with a modified action on the incident sound.

The transmission of sound involves a number of phenomena and is not a simple matter. It depends essentially on the character of the structure through which sound is transmitted and can be calculated only for simple cases of homogenous materials of known constants.

The systematic survey of the subject of soundproofing as given in the Bulletin leads to several practical conclusions.

Ventilation System.—Especial attention should be paid to the ventilation system. All effective soundproof constructions either omit entirely a ventilation system or else construct it in some special manner to avoid transmission of sound. In some buildings air is sup-

* Rayleigh, Lord. "Theory of Sound", Vol. 2, Sections 270-272, see also:
Jager, G. "Zue Theories des Nachhalls", Sitzungber. der Kaisl. Akad. der Wissenschaften in Wien. Math. Natur. Klasse, Bd. CXX, Abt. 2a, 1911.

plied and withdrawn from rooms by individual pipes that are small in diameter and extend without break from the air supply chamber to the rooms. This results in considerable friction between the walls of the pipes and the air, with a resultant weakening of the sound waves. Without some efficient control of the transference of sound through the ventilation system, it is a waste of effort to construct soundproof walls, double doors, and other contrivances for insulation.

Soundproof Partitions.—Partitions between rooms should be as rigid and free from air passages as possible. For effective soundproofing of a group of rooms, the partitions, floors, and ceilings between adjacent rooms should be made continuous and rigid. Any necessary openings for pipes, ventilators, doors, and windows should be placed in outside or corridor walls where a leakage of sound will be less objectionable.

Absorption of Sound.—The absorption of sound is an essential feature for soundproofing. Reflecting sound and scattering it still leaves it with energy. It must be absorbed; that is, converted into heat energy by friction, before it is eliminated as sound. This means that carpets, furniture, draperies, etc., should be present, or if greater absorption is desired, hairfelt or similar materials must be installed.

Soundproofing a Building.—*When soundproofing a building, all details should be considered with respect to the likelihood of transmission of sound. Each room, as far as possible, should be made an insulated unit by means of air spaces or air-filled materials that separate it from surrounding walls. Pipes and ventilators should be so installed as to minimize the chance of transfer of sound. Patent doors are now available that will close the door space at top, sides and bottom. In case a troublesome sound is generated in the room, it may be minimized by installing absorbing material on the walls.

The insulation of sound is a complex problem, and a successful solution is obtained only when all the possibilities of transfer of sound are anticipated and guarded

* "Soundproofing a Building", Architectural Forum, November, 1921.

against. While many things may be learned from further experience and much may be gained from additional theory, enough has been revealed to give encouragement to the belief that soundproofing may be prescribed in the future with some of the certainty that now attends the acoustic design of auditoriums.