DOCUMENT RESUME

ED 032 720 EF 003 231

By-Newman, Robert B.

Acoustics in Research Facilities--Control of Wanted and Unwanted Sound. Laboratory Design Notes.

Public Health Service (DHEW), Washington, D.C.

Pub Date 18 May 65

Note-6p.; Copy of lecture presented to the Division of Research Services Engineering Lecture Series, Wilson Hall, National Institutes of Health, Bethesda, Maryland.

Available from-Office of Architecture and Engineering, Division of Research Facilities and Resources, National Institutes of Health, Bethesda, Maryland 20014.

EDRS Price MF-$0.25 HC-$0.40

Descriptors-*Acoustical Environment, Acoustic Insulation, *Acoustics, Architectural Elements, Architecture, Building Design, Building Materials, Ceilings, Facility Requirements, *Laboratories, *Physical Design Needs, *Research, Standards

Common and special acoustics problems are discussed in relation to the design and construction of research facilities. Following a brief examination of design criteria for the control of wanted and unwanted sound, the technology for achieving desired results is discussed. Emphasis is given to various design procedures and materials for the control of transmission of sound from one space to another--the two basic mechanisms for achieving this purpose are noted to be absorption and isolation. (FS)

ED0 32720

Laboratory Design Notes

Distributed in the interest of improved research laboratory design

ACOUSTICS IN RESEARCH FACILITIES--CONTROL OF WANTED AND UNWANTED SOUND

by

Robert B. Newman

Associate Professor of Architecture, Massachusetts Institute of Technology
Visiting Lecturer on Acoustics, Harvard University

EF 003 231

Copy of Lecture Presented to the Division of Research Services
Engineering Lecture Series, Wilson Hall, National Institutes
of Health, Bethesda, Maryland

May 18, 1965

U.S. Department of Health, Education, and Welfare -- Public Health Service

Although research facilities have many special acoustics problems, they also have many that are common to all building types today. Modern building technique with its emphasis of lightweight construction has resulted in many buildings in which the acoustic environment is unsatisfactory. In order to improve matters, we must understand the criteria for the acoustic environment (what it is that people want and need) and apply the available technology to meet these criteria. We will have real improvement in the quality of our buildings only when designers realize that acoustics, just as structure, ventilation, and lighting is basic in the planning of every building from the single family house to the research laboratory. Good acoustics should and can be standard, not exceptional.

Before we talk about the technology for achieving results we want in buildings, we would do well to examine briefly just what our criteria for design might be. In research facilities these criteria are based both on the need for freedom from noise and vibration for the research activities that will take place and also on the need of the researches themselves to hear when they want to hear and to be free from intruding noise and distraction when this interferes with communication or research activities. In some cases we will need an almost completely silent background where any noise would interfere with the research in progress or with the audibility of sound in a lecture room or conference room. In other cases where research work is not critical in demand for silence, we may find that a well-controlled, unobtrusive background noise level will be quite helpful in giving us a sense of privacy and isolation from other activity.

Sometimes we may want a space to be very dead for activities where sound reflection is troublesome. In other situations, especially the auditorium or classroom, it may be desirable to have a large sound reflecting ceiling area. We must decide, on the basis of use, what the control measures must be, but we must exert this control by design ahead of time.

There are at our disposal two basic mechanisms for the control of transmission of sound from one space to another; absorption and isolation. Absorption of sound in useful quantities is given by porous, fuzzy materials with interconnecting air cells like carpets, draperies and glass wool, but not by closed cell foamed plastics, textured hard surfaces and most certainly not by "acoustic paint." The latter phony product has actually been advertised and sold as a sound-absorbing material.

When a sound wave (consisting of to-and-fro moving molecules in the air) encounters a porous sound-absorbing material, it loses energy in heat as the air molecules scrape back and forth on the fibers; about 75 percent of the energy is lost in a sound absorber of average effectiveness. Such a sound absorber, to be effective when applied to a hard surface, must be at least ½" thick--better 1". For the absorption of very low frequencies, even greater thicknesses are needed. Thin films of specially-designed materials can absorb sound usefully if they are spaced a foot or so away from a hard surface, but in general, one needs a fairly thick layer of material of optimum porosity for useful sound absorption.

Sometimes, for appearance or protection, a sound absorber must be faced with something durable. Whatever the facing, it must admit the sound energy to the porous material behind it either through small holes or through very thin membranes. Perforations in facing materials are usually on rather close centers ($\frac{1}{4}$" to $\frac{1}{2}$") and open up about 10 percent of the surface area. This is adequate for useful penetration of sound to the absorbing interior. Spaced wood slats are often used as facings, but neither these nor perforated materials will absorb sound unless backed by porous blankets.

A sound-absorbing treatment in a room is simply a non-reflector, it doesn't exert any suction on the sound wave. Such a treatment affects principally the quality of the room itself. It can give the space a furnished "feel." It can reduce the spreading of sound, make the space more comfortable, and make sounds seem to come from the source location and not from all over the place (by multiple reflection from hard surfaces). By controlling reflection, such treatment actually does reduce the "build-up" of sound energy in a room and lowers the average sound level. However, it does nothing near the source of sound--the operator of a noisy machine experiences almost no relief from the treatment of the ceiling in his shop. Other people farther from him may benefit, but he doesn't.

The absorption of sound in a room makes less energy available to send on to the next space, but for significant isolation, we must employ a completely different mechanism, the isolating barrier.

When a sound wave strikes a barrier, the to-and-fro moving molecules push and pull on the barrier, moving it back and forth slightly. The motion of the barrier will be determined by how heavy it is or how much inertia it has to resist this pushing and pulling. This motion of the barrier gives rise to the radiation of a new sound wave on the other side. Thus, sound energy is transmitted from one space to another by the motion of the separating barriers; the heavier the barrier, the less its motion and the less sound energy is transferred. It is important to realize that one need transmit only a ten thousandth or a hundred thousandth part of the incident sound energy to have significant audibility on the other side of a wall. For critical isolation in research, one may not be able to tolerate even a millionth part of the incident energy to be transmitted, and this always requires some very complex and expensive construction.

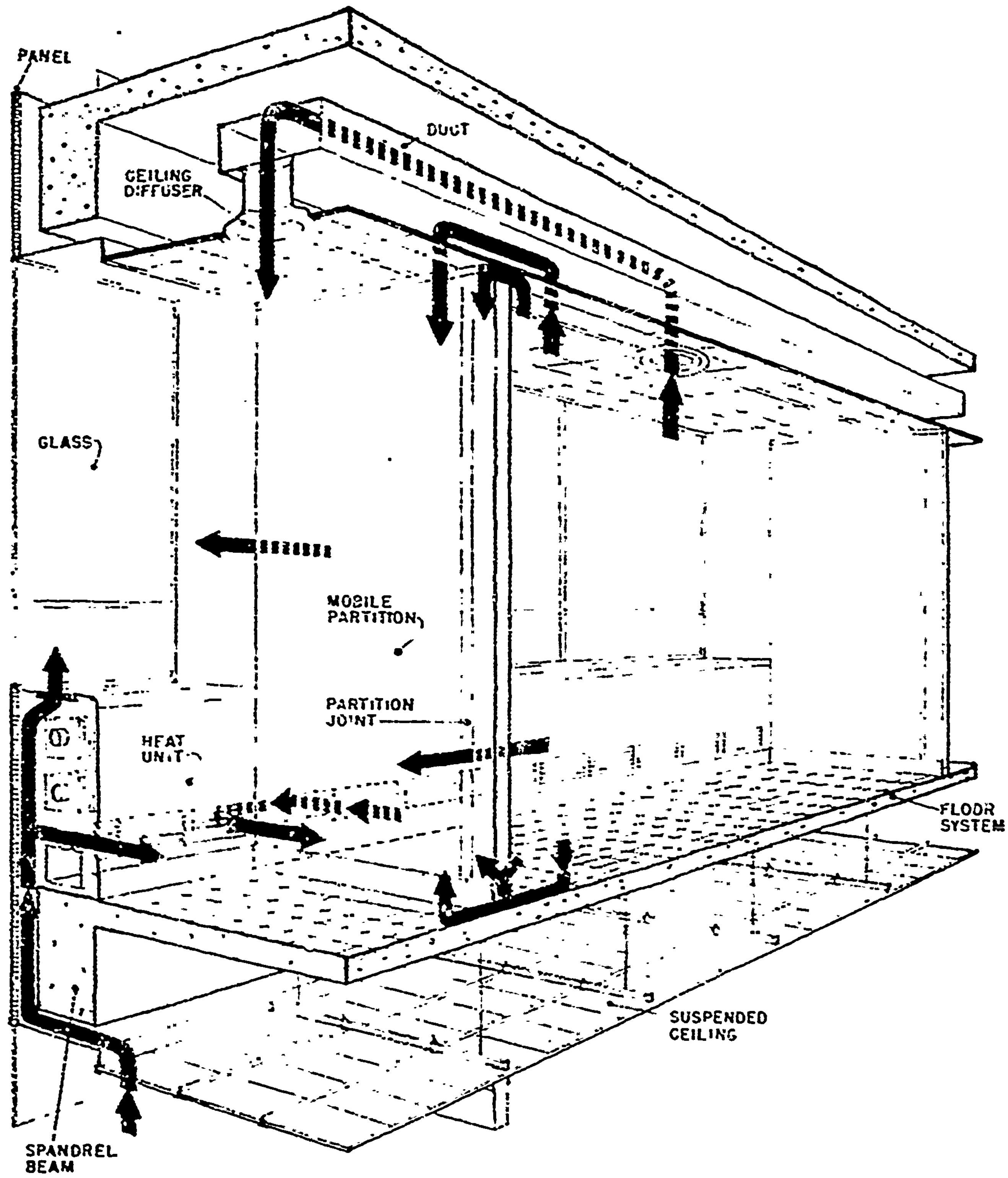
With these orders of magnitude in mind, we can readily understand why a sound absorbing material that dissipates only 70 percent or even 90 percent of the incident sound energy, will transmit a great deal more energy than can be tolerated for good sound isolation. A good sound-absorbing material is usually a miserable sound barrier. Even poorer as a barrier is an open hole or crack; this transmits 100 percent of the sound energy that strikes it.

In addition to the sound wave in air that transmits energy to the walls and floor, we have direct transmission of energy by impact. Machinery mounted directly on the structure without resilient breaks, people walking on bare, hard-surfaced floors, pianos and other floor-driving musical instruments give rise to direct motion of the barrier and consequent sound radiation.

Only by preventing direct impact by resilient mounting or surfacing can this type of noise transmission be controlled.

The application of the various noise control techniques takes many forms, but basically we must remember the differences between the uses of sound-absorbing and sound-isolating materials. Each has its own place and each does only part of the total job.

We might, first of all, look at the more ordinary problem of isolating offices and non-critical laboratories from each other. In the accompanying figure we have shown a typical curtain wall concrete frame building with service plenum above a suspended ceiling.



We have indicated a movable partition, under-window heating unit, overhead diffuser for air circulation, and most of the typical situations that occur in a building. We have also shown here the paths by which sound can leak from one space to another. Each of these paths must be controlled, or the overall result will be less than satisfactory. Sound goes readily through every leak and crack between the elements of the movable partition system and where these units join the ceiling, floor, and outside wall. Sound will travel through the cabinet work for the heating unit unless this is sealed off underneath. Sound may go through the sound-absorbing ceiling which is often transparent to sound, although it is an effective sound absorber. Sound is sometimes conducted from floor to floor between the curtain wall panel and the structural spandrel beams or sometimes through the curtain wall panel itself. The greatest problem in modern buildings with lightweight, dry, prefabricated components making up the interior subdivisions and the exterior cladding is the sealing of all these members to make them airtight and thus potentially sound tight.

When sound isolation problems are more critical for laboratory research work, it is probable that movable construction will not satisfy the requirements and that heavy, more permanent installations will be needed. In very critical situations (e.g. for audiometry) it may be necessary to "float" a room within a room, using resilient separators for the entire inner skin of plaster and concrete. This also requires separate lined ducts for supply and return of air, specially weatherstripped doors, etc.

In some special rooms for auditory testing or acoustic calibration, it may be desirable to simulate free field acoustics conditions. These "anechoic" rooms require quite deep and complex sound absorbing linings in addition to very high sound isolation. These linings take the form of glass fiber wedges (2' to 4' deep) or ribbons of glass fiber materials. Special wire floors are usually suspended over the floor treatment to enable the experiments to be conducted in a reflection-free environment.

In addition to the basic problem of noise control in various degrees between spaces in research facilities, there are spaces such as lecture rooms and auditoria in which we simply want to hear well. In such rooms, the background noise should be inaudible. The sound absorbing treatment required for the control of reverberation should be placed on rear wall and side walls surfaces, or sometimes in peripheral ceiling areas. But the main portion of the ceiling should <u>always</u> be hard and sound reflecting. In this situation we want the sound distribution to be improved by reflection from the ceiling. We don't want a noise control treatment here.

A well designed "conference" auditorium can seat 300-400 people with good audibility of speech sound from all parts of the room with no need for electronic amplification. The freedom from microphones adds tremendously to the usefulness of the room. Such an auditorium should have a well pitched or stepped floor, fabric upholstered seats to keep the reverberant characteristics more or less constant with varying audience size, an adequate ceiling height (20' or so) and a generally squarish plan. The walls must be treated or shaped to avoid parallelism that would give flutter echoes across the room, and every effort must be made to keep out external noise. The ceiling shape will be determined by the seating arrangement and the needs for lighting, movie sound system and ventilating outlets.

Smaller lecture rooms and classrooms can be less elaborately done, but they too deserve careful attention to details for proper distribution of sound reflecting and absorbing materials, control of noise from ventilating systems, slide projectors, and surrounding circulation areas.

Good acoustics in research facilities won't happen automatically. The techniques for achieving good results are well understood today, but they must be applied carefully throughout the design and construction phases of building--good acoustics can't be pasted in later.

Additional copies of this leaflet may be obtained from. Office of Architecture and Engineering, Division of Research Facilities and Resources, National Institutes of Health, Bethesda, Maryland 20014