MISTAKEN IDEAS CONCERNING SOUND ABSORBERS

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There are today so many school rooms, churches, and other buildings that are bad from the standpoint of acoustics, and so many others are being erected with no scientific consideration of the question of what their acoustical properties will prove to be, that it seems to be high time for architects to awaken to the fact that an auditorium is for auditors, that in an auditorium hearing is more important than seeing. Most of them have not yet awakened. We continue to build churches, community buildings and all sorts of assembly rooms utterly unfit for the very purpose for which they are intended. When building a house we would not employ an architect who would plan bed rooms in which one could not comfortably sleep, or kitchens in which good food could not be prepared. But we continue to employ architects to build auditoriums for which we should coin a new word, *spectatoriums*, as the only consideration given the auditor is "how many will the room seat and each one see the pulpit or stage?"

It is not the purpose of this paper to set forth the laws or principles of acoustics by which the architect must be guided in planning a satisfactory auditorium. I wish merely to direct attention to "some mistaken ideas concerning sound absorption," ideas which are more or less general and some of which, I regret to say, have found their way into text books.

(1) *Sound Mirrors.* A fine silver mirror reflects a smaller per cent of the light that falls upon it than an ordinary plaster wall reflects of the sound striking the wall. In other words, an ordinary room with plaster walls, glass windows, wood doors and wood floor is a sound mirror room in which there would be more numerous sound reflections and sound images than there would be light reflections and multiple light images in a room without windows, doors or other openings and having all walls, ceiling and floor of the finest quality of plate glass mirrors. If the floor of the sound room were of cement and the walls of tile or glazed brick, as a sound mirror room it would far surpass the plate glass mirror room for light. In fact, the plate glass mirror room itself would reflect more sound energy than light energy. It is therefore very evident that concave surfaces act as condensing mirrors, and are to be avoided. If present they must be covered with a substance having as high a coefficient of absorption as possible. No amount of sound absorbing material used elsewhere will eliminate the unequal sound distribution such curved surfaces always produce.

(2) *Sound Absorbing Materials.* That a soft, yielding substance is a better sound absorber than one that is hard and rigid is not necessarily true. For instance, what is called sponge rubber (like that of rubber bath sponges) is not as good a sound absorber as is acoustic palster, a hard and comparatively inelastic material. The plaster owes its absorptive properties to its porosity—to the small holes that have been blown in it by gas, chemically formed and escaping while the plaster is setting, or hardening. The sponge rubber appears to be full of pores. A closer examination shows it be be made up of numerous air cells, each entirely enclosed in rubber, and to be practically non-porous. It is therefore a poor sound absorber.

Porosity being the most essential property of a good sound absorber, it should be clear that anything that closes the pores of a substance must materially reduce its ability to absorb sound. The surface of a sound absorbing material can not be covered with varnish or a pigment paint without lowering its sound absorption coefficient. Perhaps it is unnecessary to add that the acoustics of a room can not be improved by placing in it vases, statuary, or anyting made of glass, stone, metal, or any other rigid and non-porous substance. If a hundred miles of wire were stretched back and forth across a room, the improvement in its acoutics would be negligible.

(3) *Sound Absorption of Audience.* Most tables of sound absorption coefficients give a value above 4 units for the absorption of an audience per person, averaging perhaps about 4.7 units. Some tables give 4.5 units per man and 5.4 units per "isolated" women. The latter value might have been about right thirty years ago when women wore a total of forty or fifty yards of drapery, but not today. In a recent publication[1] I have advised that in the case of new talking picture theaters the audience absorption be calculated on the basis of three units per person—a value lower than recommended by others. There are four reasons for recommending so low a value, the first—as mentioned above—being the fact that women and children wear far less clothing than they did when the high absorption values were experimentally obtained. A second reason is that talking picture houses are usually seated, with chairs covered with more or less upholstery, to which the absorbing power of the chair is chiefly due. A person seated in such a chair covers the upholstery, and at the same time the area of his body exposed to sound waves is diminished. A third reason is that talking picture audiences usually include many children, who present less sound absorbing surface than do grown-ups. A fourth reason is that it is highly desirable to reduce the reverberation period of a "talkie theater" to a lower value than is permissible for a church or "legitimate stage" theater. At best reverberation is more or less of a disturbing factor which might best be reduced to the lowest possible limit were it not for the fact that a certain amount of sound reflection is necessary in order for a speaker or actor to make himself heard in a large room. But in the case of talking pictures the volume of the sound can be increased almost at will, so that reverberation is not necessary to give sufficient sound intensity for satisfactory hearing. Consequently for talking picture theaters I am recommending reverberation periods not to exceed one second—considerably lower than text books recommend for theaters and music halls.

(4) *Location of Sound Absorbing Material.* It is frequently stated that the effect of sound absorbing material is independent of where it is placed—whether on walls, ceiling, or floor. The statement is practically true in certain cases only and where reverberation only is considered. Evidently it could not be true for sound distribution in case the room has any sound mirror surfaces, as explained in paragraph (1).

Again, it is practically true only where the sound is produced at considerable distances from the sound absorbing material. As an illustration consider a sound source S (fig. 1) and let us confine our attention to the sound energy emitted from the source between the directions S L and S M, which, when reflected, would pass to the opposite wall between the lines L N and L O. Covering the near wall for a space L M would produce as much sound absorption

[1]Acustics of Talking Picture Theaters. Published by The Starr Piano Company, Richmond, Indiana.

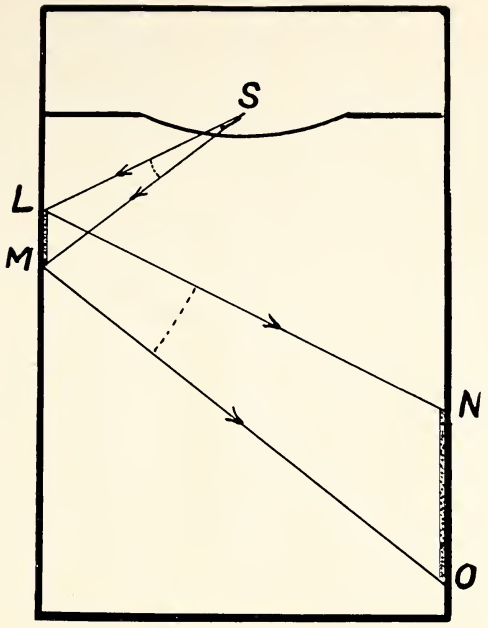

Fig. 1

(really a trifle more) than would covering the larger space N O of the second wall. The material required to cover the space N O and which would absorb but a small fraction of the total energy emitted by S would absorb all, or nearly all of it, if wound in the form of a tube surrounding S.

Consider another illustration. Suppose we place a sound absorbent over an open window. It would actually increase the reverberation in the room, as the material would reflect a portion of the sound which the uncovered window would transmit in toto.

It *does* make a difference where the sound absorbent is placed. Other things being equal, the material should always be placed over the portion of the wall or ceiling that has the lowest coefficient of absorption at the outset. However, even this rule has exceptions.

Let us suppose a theater with perfectly absorbing side walls, floor, ceiling and stage, but a hard plaster end wall opposite the stage. The reverberation period of such a room would be very small, much smaller than the one second limit given in paragraph (3). A speaker standing near the rear reflecting wall would notice no reverberation, as the time interval between his spoken word and its return to him by reflection from the near wall would be very short. Should he speak on the stage the sound wave would require time enough to travel twice the length of the room before reaching his ear the second time. This would produce a disagreeable echo—what is known as a sound "back slap." Some absorbing material on the far end wall of the room is absolutely necessary to remedy such a condition. Unless the reflection from the rear end of a room is broken by balconies or the equivalent, the wall should be partially or wholly

covered with acoustic absorbing material, the amount depending on other features of the room.

Space forbids a discussion of numerous other mistaken ideas, such, for instance, as the belief that a cone loud speaker has a sound directive effect; that troublesome reverberation in a large auditorium can be corrected by using several loud speakers installed in different parts of the room; that a few flags or a little bunting can materially improve bad acoustics; that baffle boards are resonators or that they should be covered with sound absorbing material, and so on. I shall consider but one of these mistaken ideas, the one having to do with horns, sounding boards, and other resonators. Such things do not function at all in the way they are quite generally supposed to function. Reference to figure 2 will illustrate the point. A would-be inventor has taken out a patent

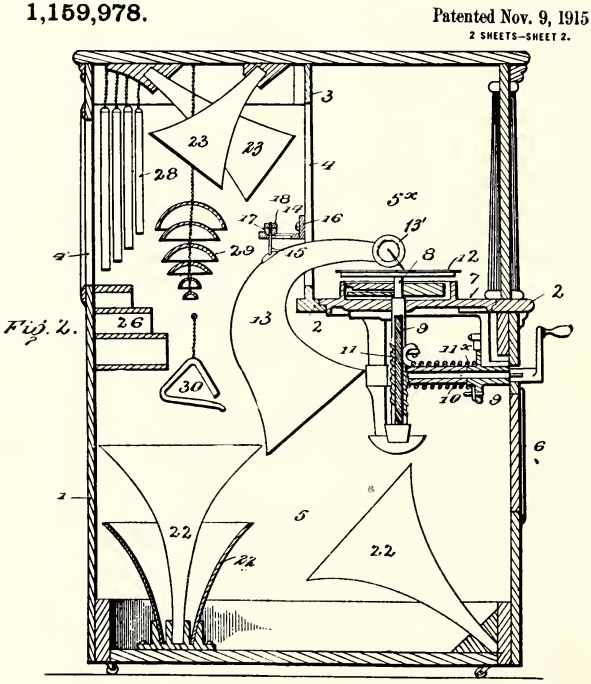

Fig. 2

on a phonograph with a case containing horns of various sizes, triangles, bells, chimes, and organ pipes. Another inventor, in addition to the above items, included a xylophone and harp in his design of a phonograph cabinet, evidently expecting each to reinforce by resonance the particular pitch and quality of sound that it would give if itself a sound source. Such things are powerless to affect sound quality or intensity in the slightest degree. It would be just as effective to put in the case a picture of a bull frog to reinforce the low notes of a bass singer. A piano sounding board is not thrown in vibration by the sound waves produced by the string, but by the vibrations communicated from the

string to the board through the wood and metal by which they are connected. A sounding board held in front of a vibrating string but not connected to it in any way, will *not* increase sound intensity. Indeed, it will reduce it.

The only reason a horn increases the intensity of the sound from a phonograph reproducer is that the reproducer diaphragm, being forced to vibrate inside a closed body of air, is made to *do more work* than if it vibrated in the open.

A baffle on a cone speaker increases sound intensity—not by vibration or resonance—but by preventing destructive interference of sound waves. Remembering that waves produced by the rear surface of the cone are always in opposite phase to those produced by the front surface, sound intensity can be increased by preventing their union while in opposition. A baffle should be reflecting, not absorbing. It should be rigid, not resonant. It should not be in contact with the loud speaker, either directly or indirectly.

Applying to the case of a theater with a resonant floor or side wall, no decrease in reverberation can be brought about by stiffening or fastening the vibrating member so it can not vibrate. No body can give out more energy than it absorbs. Should a side wall be thrown into vibration by sound waves falling upon it, the vibrations can not give out any more sound energy than was taken from the original sound in producing those vibrations. And since a vibrating wall produces as much sound on one side as on the other, half the energy absorbed in resonance is liberated outside the room. Thus the sound intensity inside the room is *diminished* rather than augmented by a resonating wall.

Much money and inventive effort would be saved if false ideas concerning sound phenomena were not so prevalent.