A NEW, EFFICIENT AND ECONOMICAL TYPE OF SOUND ABSORBING MATERIAL, AND A SIMPLE AND INEXPENSIVE METHOD OF INSTALLATION

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My first detailed study of the problem of correcting faulty acoustics was in the year 1919 when I was asked to improve the hearing in the auditorium of the Student Building of Indiana University. Bids were taken from firms making a business of acoustic correction. As they ran much higher than the sum the University could allow for the purpose, I undertook the job myself and evolved an entirely new plan for the purpose. The scheme was described to the Indiana Academy of Science at the annual meeting in Indianapolis, Indiana, December, 1919, under the title "Correction of the Acoustics of the Auditorium of the Student Building of Indiana University" (P. 46, Proc. Ind. Acad. Sci., 1919). I did not submit the paper for publication, waiting to learn how well the installation would stand the test of time.

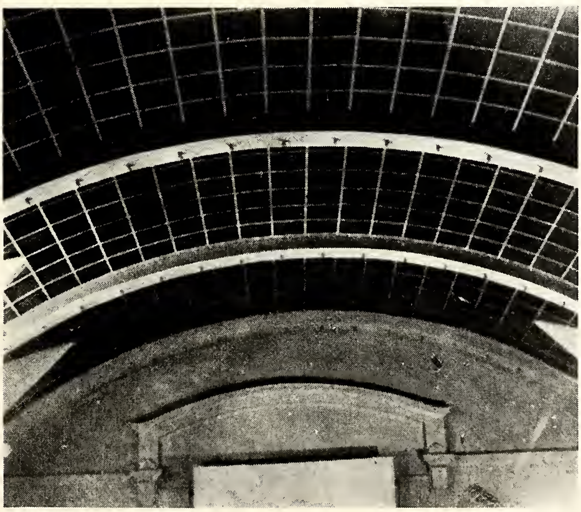

Fig. 1.

Figure 1 is a picture showing the barrel shaped ceiling which was chiefly responsible for the very unequal sound distribution and the all but impossible hearing in the room before correction. The picture shows the ceiling after correction. Imagine that, instead of the panels, the ceiling between the arched beams is plain plaster, and we have a picture of it before correction. Bidders had figured on covering the entire ceiling with sound absorbing material. I adopted an entirely different plan. I removed the wire lath and plastering between the arched beams and in its place securely fastened wood strips or grounds to which was nailed screen wire. The distance between the grounds was such that the stips of screen wire were nailed along the edge only, each ground supporting the two wire strips on its sides. After the wire screen was in place the wire joints were hidden by nailing over them a wood strip or mold. Cross strips were used to give a panel effect. Behind the wire screen was placed the absorbing material, giving the finished appearance shown in the figure. The installation not only reduced the reverberation, but it completely eliminated the uneven sound distribution due to the condensing mirror effect of the barrel shaped plaster ceiling.

The reader may wonder why the plaster ceiling was removed, since the ground could have been fixed directly to it and the screen wire with absorbent behind it placed in position and paneled without removing the plaster. The plaster was removed to eliminate entirely its focussing effect, which could not have been done otherwise. The best absorbing material I could have placed behind the wire would have absorbed but fifty to sixty per cent of the sound energy falling upon it, leaving a third to half the sound to be reflected by the plaster wall behind the absorbent. Removing the plaster permitted the sound to pass into the attic where there were no concave sound mirrors, and where wood beams, rafters, sheathing, etc., by their absorption, greatly reduced the amount of material needed on the screen wire.

Another reason for removing the plaster was that the architectural effect of the projecting arched beams was not imparied by reducing that projection, as would have resulted had the ceiling between them been lowered by placing absorbing material under it.

I have recently filed an application for a patent on a method of applying sound absorbing material to any wall, ceiling, or other surface, a method essentially like that used in the Student Building years ago. Together with the Superintendent of the company manufacturing Balsam Wool sound absorbent, I have applied for a second patent, this one covering the facing of Balsam Wool with screen wire, the wire projecting a half inch beyond the edge of the wool for nailing to the wood ground.

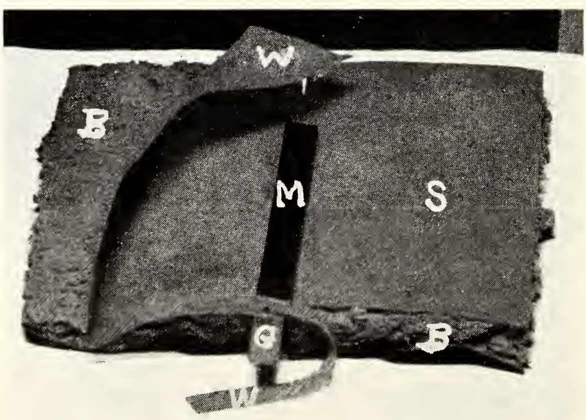

Fig 2

Figure 2 is a picture of a small piece of the material. S is the screen wire surface of the material as it appears when the observer is quite close to it. At a distance greater than eight or ten feet the mesh of the wire is practically invisible. W is a portion of the wire torn loose and folded back to show the fibrous (and porous) structure of the Balsam Wool B. P is the wire projecting beyond the edge of the wool. G is the ground to which the two pieces of absorber are nailed, and M is the mold to hide the wire joint and give a finished appearance to an installation. Note that the ground is of the same thickenss as the absorbing material.

Both patents have been assigned to the company which has been manufacturing cloth faced Balsam Wool for several years, and which is now marketing the wire faced product

The chief steps in the manufacturing process are as follows: Wood, largely waste from northern Minnesota saw mills, is shredded and treated chemically to make it vermin proof, and as nearly fire-proof as possible. After being sprayed with a water-proof adhesive the fiber itself is sprayed to a uniform thickness (usually an inch) on screen wire. Adhesive coated crepe or Kraft paper applied to the upper surface (the one opposite the screen wire) completes the job.

When weighing the merits and demerits of a sound absorbing material there are many points that should be considered. I shall mention some of the more important ones.

(1) An acoustic absorber should have a high absorption coefficient, and one as nearly uniform as possible for all common sound frequencies, or pitches.

The higher the absorption coefficient the smaller the amount of material required on any particular job, the smaller the expense of applying the material, and the better the chance of being able to apply it in the most convenient and otherwise desirable place. From our previous discussion of concave surfaces it is evident that such surfaces demand an absorbent having a high absorption coefficient.

If the absorption of an acoustic material is highly selective, it is efficient for sounds of certain pitches only. This results in a change in the quality of sounds reaching the ears of the audience.

The table below gives the absorption coefficients of Balsam Wool (determined by the writer) compared with the average coefficients of seven other advertised acoustic absorbents.

Absorption Coefficients

Frequency—Double Vibrations per second	128	256	512	1024	2048	4096
Absorption Coefficients of wire screen covered Balsam Wool	.09	.26	.48	.64	.55	.40
Average of the Absorption Coefficients of *seven* other advertised acoustic absorbers	.08	.21	.33	.47	.46	.38

(2) An acoustic absorber should be cheap, to buy and to install. However cheap the purchase price of an absorber may be, if it requires the services of expert or experienced men to apply it, its installation is necessarily expensive. It is evident that the method of application described in this paper is so simple that any carpenter, even a "saw and hatchet" carpenter, should be able to do the work satisfactorily. As a matter of fact, the total cost of acoustic correction

with screen wire faced absorbent as previously described should be from one-fifth to one-half the expense by other methods.

(3) Other things being equal, a light weight absorbing material has many points of superiority over a heavy material. Freight and drayage charges are less, the material can be handled more easily and threfore installed more economically, grounds for supporting the materials may be lighter and their attachment to walls and ceilings less secure, and no strengthening of wall or ceiling structure is necessary to carry the extra load of the applied absorbent.

Screen wire faced Balsam Wool weighs but 6.24 ounces per square foot, the lightest absorbent of which the author has any knowledge.

As an instance of the advantage of a very light weight material, I cite the the case of one Indianapolis theater in which there was a large duck awning over the central portion of the gallery in the rear. The upper surfaces of the ducking could not be seen from any part of the main floor or gallery. Upon my recommendation strips of Balsam Wool 30 inches wide and extending full length of the awning were laid over the ducking—no attachment was necessary. The wool was so light that it produced no perceptible sagging of the ducking. Three hundred square feet of absorber were thus applied.

(4) Reference to Figures 3 and 4 gives some idea of the fire resisting qualities of screen wire faced Balsam Wool.

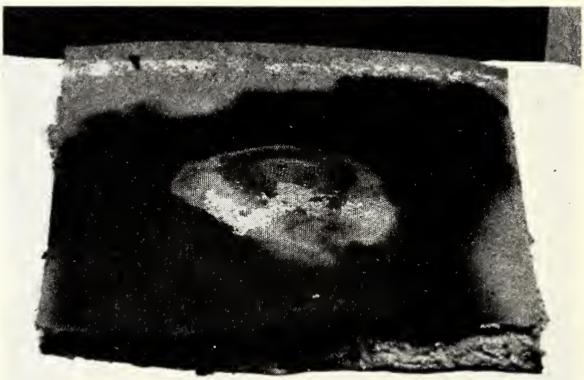

Fig. 3

Figure 3 is a photograph of a piece of wire faced Balsam Wool after being held in a horizontal position, wire screen surface below, directly in the flame of an alcohol burner with wick three inches in diameter. An alcohol flame was used instead of a gas flame to avoid a carbon deposit from the flame itself. The picture shows the blackening of the wire due to the charring of the Balsam Wool immediately behind it. When the wire was stripped off and the wool examined it was found that the charring did not extend to a depth of more than an eighth of an inch.

Figure 4 shows the result of subjecting a piece of screen wire faced Balsam Wool to the blue flame from a large blast burner designed for blowing glass. The absorbent was applied to a vertical wall and the horizontal blast directed against the wire facing. In a second or two the wire facing became red hot (white hot near the center of the flame) over a space about five inches in diameter. At 45 seconds one of the wires burned in two and two or three more followed within five seconds. This occurred at the oxidizing tip of the blast. After five minutes the hole was but three-eights inches in diameter—five wires burned in two. One minute after the blast was applied the flame passed through the hole in the screen and could be seen behind it. At the end of three minutes the wool had been carbonized through to the wall, and was emitting considerable smoke. Two minutes additional exposure increased the size of the cavity in the

Fig. 4

wool to a diameter of approximately seven inches. When the blast was removed the wool continued to smoke for some two minutes. There was no flame, but the thoroughly carbonized wood fiber was evidently burning where it had been directly in the path of the flame. The glow died out rapidly and was entirely gone within two minutes after the blast was removed.

The dark streak along the lower edge of the surface of the screen wire in figure 3 was produced by a white hot nichrome wire which was kept lying in contact with it for five minutes. The effect is confined chiefly to the end contacts. Between these points the screen wire carried a part of the current, the temperature of that portion of the nichrome wire being considerably reduced. Evidently the wire screen materially reduces fire hazards from overheated electric wires, as well as those arising from other causes.