# Virtual Education Lab: Introducing a new acoustical surface treatment called the Returner.

Thus far in the Reflection syllabus, we discussed what is required to create a specular reflection, with examples of specular reflections from room boundaries, consoles, semicylinders, triangles, and pyramids.

In this post, we describe how the concept of a corner reflector can be used to create a new acoustical surface treatment called a Returner, which scatters sound back to the source.

In Figure 1, we compare the temporal and spatial responses of a Reflecter and a special case of the Reflecter called the Returner.

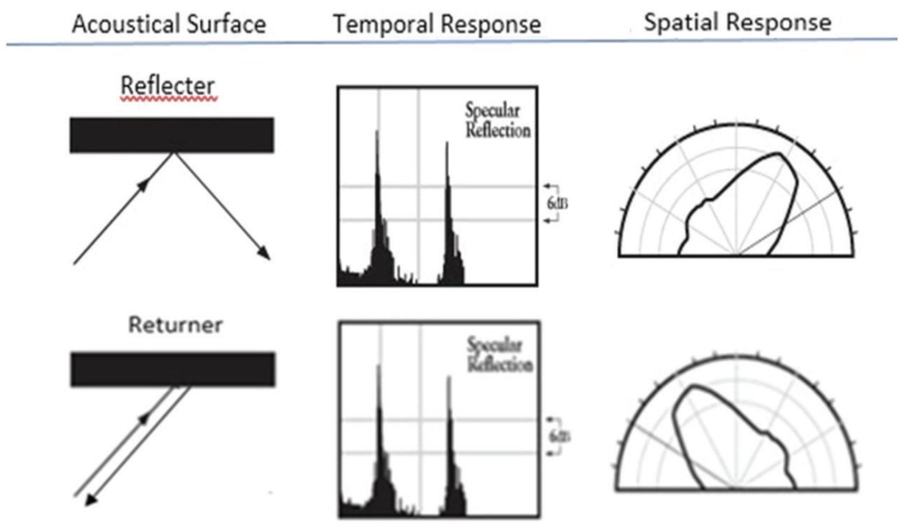


*Figure 1. Temporal and spatial responses for a Reflecter and Returner.*

In DR 220825, we described the special case in which two adjacent triangles with an interior angle of 45º scattered normally incident sound back in the direction of the source. The Returner is a 3D surface, schematically shown in Figure 2, consisting of three mutually perpendicular planes.

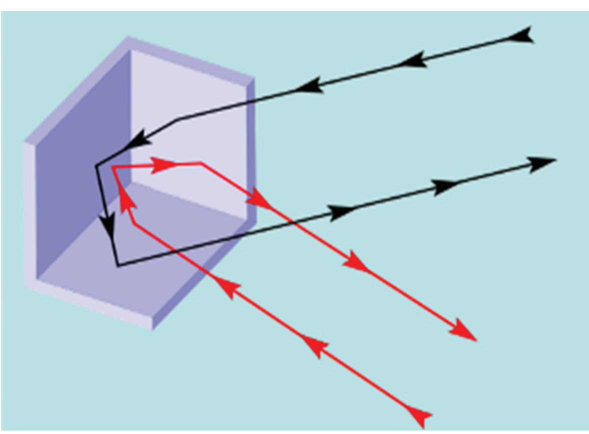

*Figure 2. Triple specular reflections from three mutually perpendicular planes, which scatter sound back to the incident direction for two angles of incidence.*

Due to the mutually perpendicular sides, incident sound is reflected three times at specular angles and redirected back to the incident direction, *from any source direction.* This is an extension of the 2D triangular case described in DR 220825, for normally incident sound, similar to a boomerang!

To effectively utilize an array of corner reflectors, we can design a device called a triangular tetrahedron with an open triangular bottom (Figure 3), whose plane faces the incident sound. The sides of the equilateral triangle are given by a, b, and c, and the open base of the tetrahedron has sides e, f, and g.

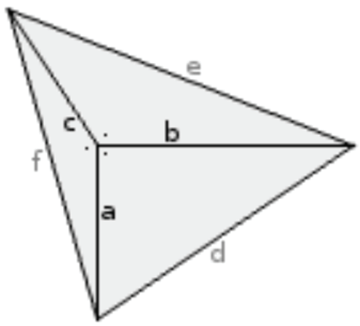


Figure 3. Open bottom triangular tetrahedron.

A useful application is to combine these tetrahedral elements into a multi-element array to cover any desired surface area in applications which benefit from this unique “boomerang” capability. Applications include an office or teleconference environment in which the redirected sound back to the speaker will passively amplify their speech and encourage them to lower their voice, thus creating less of a noise disturbance. A ceiling application is shown in Figure 4.

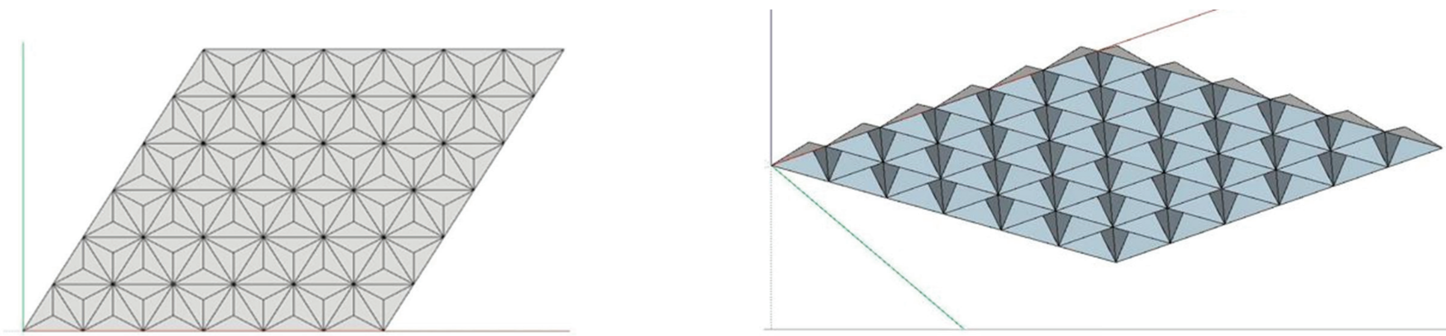

*Figure 4. Array of triangular tetrahedra in a ceiling. Left: Reflected ceiling plan; Right: isometric view.*

To demonstrate the performance of this Returner, a comparison of the polar scattering between a flat panel and the 3D corner Returner is shown in Figure 5, where the angle of incidence is indicated with an arrow at -60°, with respect to the normal, and the +60° specular reflection direction is shown as a gray triangle.

This concludes our syllabus on Reflection. The next syllabus in our continuing educational curriculum, as part of the Virtual Education Lab, will be Diffusion.

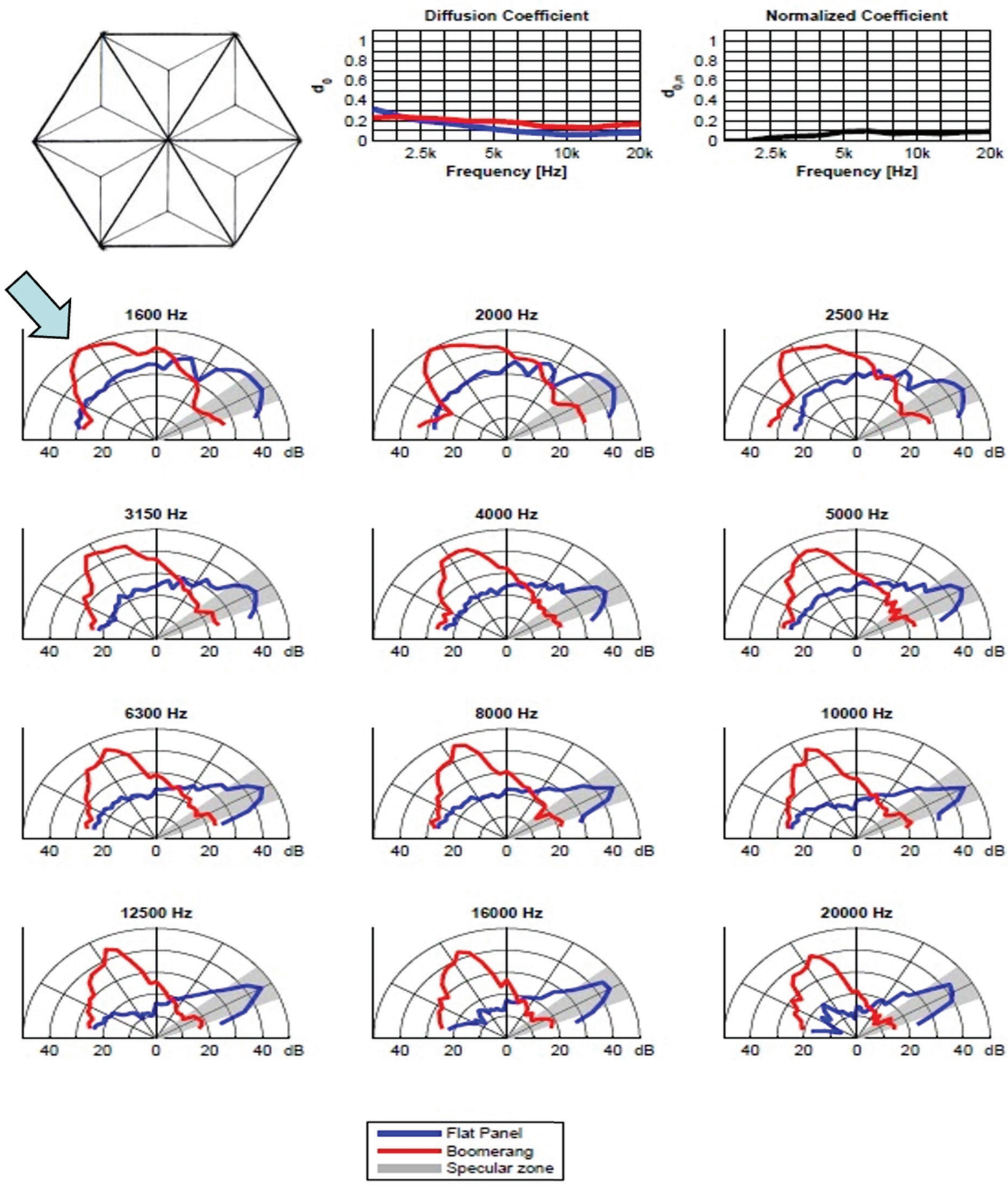


*Figure 5. The diffusion coefficient and polar reponses comparison between a flat panel (blue) and the Returner (Boomerang red) is shown between 1,600 Hz and 20,000 Hz. The arrow indicates the incident sound direction.*

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