Virtual Education Lab: The origin of a uniform sound diffuser

We begin the diffusion syllabus with an introduction to the origin of the reflection phase grating diffuser, commonly known today as an RPG diffuser. In a continuing series of posts, we will follow this genesis with a complete description of its evolution and ISO measurement standardization.

Classic architecture or classically-inspired architecture benefits from the fact that scattering surfaces, in the form of columns, statuary, balustrades, coffered ceilings and relief ornamentation, were an integral part of the design. As architecture evolved into using less ornate surfaces with smooth rectilinear forms, this created a need to design new scattering surfaces to complement contemporary architecture. The RPG was the beginning of this journey.

Figure 1. Carl Friedrich Gauss

The story of how quantifiable scattering surfaces evolved begins in the 19th century in Gottingen, Germany, where Carl Friedrich Gauss, Figure 1, discovered quadratic residue sequences and much more, with no practical application in mind.

Figure 2. Manfred R. Schroeder

In a paper entitled "Binaural dissimilarity and optimum ceilings for concert halls: More lateral sound diffusion" (J. Acoust. Soc. Am. 65(4), Apr. 1979), Manfred Schroeder, Figure 2, proposed the use of quadratic residue and other number theoretic sequences, which have a flat power spectrum to uniformly diffuse soundwaves over a broad bandwidth.

The quadratic residue number theory sequence formula is shown at the right, where S_n is the nth sequence number, *n* is an integer, *mod* or *modulo* indicates the least non-negative remainder, *N* is the number generator, which in this case is also a prime and the number of wells per period.

$$S_n = n^2 \bmod N$$

A lateral cross section of two periods of a reflection phase grating, quadratic residue diffusor, QRD, with N=17 is shown in Figure 3. The width of a divided well is w and Nw represents the width of one period of the QRD, with a total depth d. The depth of the nth well, d_n, is determined from the sequence values S_n, and the corresponding design wavelength λ_o.

$$d_n = \frac{S_n \lambda_0}{2N}$$

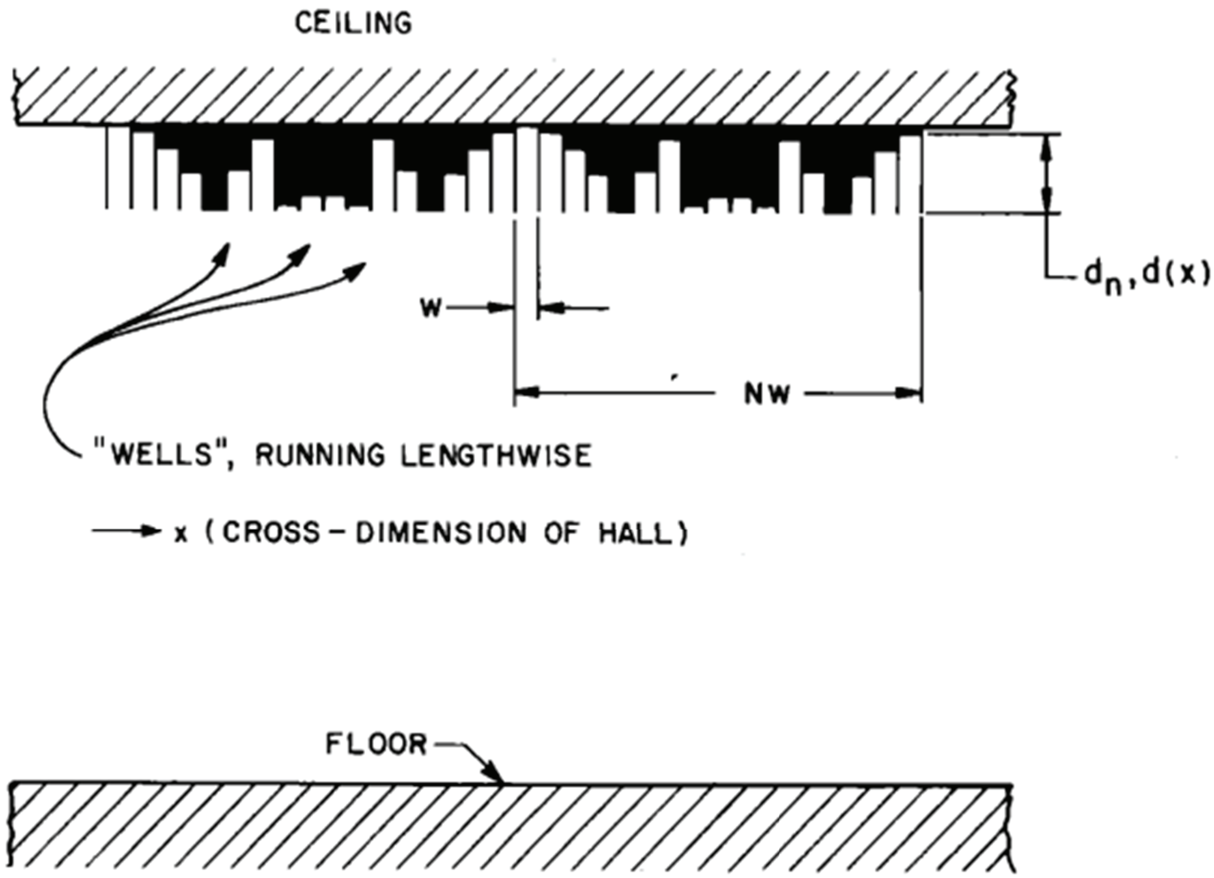

Figure 4. Cross section of two periods of a QRD based on N = 17.

In the subsequent posts in this diffusion syllabus, we will continue to describe the evolution of this new acoustical surface treatment and discuss my introduction into this interesting story.

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