



# A fundamental study on the sound radiation from ribbed vibrating panels

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## REFLECTIONS TITLE

A fundamental study on the sound radiation from ribbed vibrating panels

## ARTICLE REFERENCE

Article Title: Response of Ribbed Panels to Reverberant Acoustic Fields

Author: Gideon Maidanik

Publication Date: Month Year (JASA Vol#, FirstPage#); DOI-link

JASA **34**, 809 (1962); doi: 10.1121/1.1918200

## ARTICLE OVERVIEW

At first glance, the title of Maidanik's paper<sup>1</sup> suggests that it focuses mainly in the vibratory response of ribbed panels when excited by a diffuse acoustic field. This is not really the case, since the scientific contributions of this paper are mainly concerned with understanding the acoustic radiation of ribbed (and unribbed) panels. To understand where this supposed "inconsistency" comes from, we need to understand that this paper is part of a collection of articles written in the early sixties by a team of talented researchers at Bolt Beranek and Newman (BBN) Inc. and which would give rise to the well-known Statistical Energy Analysis (SEA) method<sup>2,3</sup>. Indeed, a few months earlier, under certain assumptions, Smith<sup>4</sup> on the one hand, and Lyon and Maidanik<sup>5</sup> on the other, had demonstrated, using different concepts, a reciprocity relationship concerning the coupling between a vibrating structure and an acoustic medium. It states that the coupling coefficient linking the mean vibratory velocity of a panel excited by a diffuse acoustic field to the pressure autospectrum of the diffuse field can be determined from knowledge of a panel's radiation resistance. Since the latter is more readily available, either theoretically or experimentally, Maidanik investigated the radiation resistance of ribbed panels (in a light fluid) to achieve his goal.

Maidanik's study on the acoustic radiation of panels led to two major contributions:

- On the one hand, he provided a detailed analysis of the radiation mechanisms of simple panels (i.e. unribbed panels). He highlighted different regimes, particularly below the panel's critical frequency. By conceptually replacing the panel's vibratory field with a two-dimensional array of rectangular piston radiators, he highlighted the radiation of so-called edge modes and corner modes, as well as the different contributions of the modes depending on the parity of their modal indices. Finally, he arrived at the famous equations (2.39) to (2.42) (including the correction in the erratum<sup>6</sup>), which enable the radiation resistance to be calculated analytically. He also showed that for an extended frequency range below the critical frequency, the radiation resistance is proportional to the perimeter of the panel (and not to its area), and that the radiation resistance of a panel with clamped boundaries would be twice that of the simply supported case.

- On the other hand, he showed that below the critical frequency, a ribbed panel radiates more than the same panel without ribbing. Under certain assumptions, he estimated that stiffeners led to an increase in the panel's radiation resistance by a factor equal to:

$$\frac{P^{ribs} + P^{panel}}{P^{panel}},$$

where  $P^{ribs}$  is twice the total length of the ribs and  $P^{panel}$  is the perimeter of the original panel.

The study was supplemented by experimental investigations. The measurements verified certain assumptions considered in the theoretical developments. They also clearly demonstrated a significant increase of the radiation resistance due to the presence of stiffeners, as predicted by Maidanik's model. Finally, he concluded that *"the agreement between theory and experiments is promising"*.

## IMPACT OF THE ARTICLE

Maidanik's seminal work had three kinds of repercussions:

- The analytical formulas he proposed for the radiation resistance of an un-ribbed panel have become references for the scientific community and have been presented in numerous textbooks. In addition, many authors have subsequently sought to refine the prediction of panel radiation efficiency. For instance, Wallace<sup>7</sup> provided low-frequency asymptotic solutions for simply-supported plates, Gomperts<sup>8</sup> and Berry et al.<sup>9</sup> extended the results to other boundary conditions, while Laulagnet<sup>10</sup> studied the radiation efficiency of a non-baffled plate.

- The theoretical developments proposed, together with the underlying assumptions (energy equipartition, vibratory diffuse field, weak coupling, etc.), were pioneering in the development of the SEA method, which would be formalized in the following years by the BBN team. This work is undoubtedly associated with the fundamentals of SEA.

- As stiffened structures are very common in engineering applications, and as Maidanik highlighted that stiffeners make a significant contribution to panel radiation, numerous subsequent studies have sought to improve understanding of the radiation mechanisms of this type of structure.

by Laurent MAXIT

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## REFERENCES

- <sup>1</sup>G. Maidanik, "Response of ribbed panels to reverberant acoustic fields," J. Acoust. Soc. Am. **34**, 809-826 (1962).
- <sup>2</sup>R. Lyon, R. Dejong, "Theory and application of statistical energy analysis," Butterworth-Heinemann, Newton, USA, 1995.
- <sup>3</sup>A. Le Bot, "Foundation of statistical energy analysis in vibroacoustics," Oxford university press, Oxford, UK, 2015.
- <sup>4</sup>P.W. Smith, "Response and radiation of structural modes excited by sound," J. Acoust. Soc. Am. **34**, 640-647 (1962).
- <sup>5</sup>R.H. Lyon and G. Maidanik, "Power flow between linearly coupled oscillators," J. Acoust. Soc. Am. **34**, 623-639 (1962).
- <sup>6</sup>G. Maidanik, "Erratum: "Response of ribbed panels to reverberant acoustic fields," [G. Maidanik, J. Acoust. Soc. Am. **34**, 809-826 (1962)," J. Acoust. Soc. Am. **57**, 1552 (1975)

<sup>7</sup>C.E. Wallace, "Radiation resistance of a rectangular panel," J. Acoust. Soc. Am. **51**, 946-952 (1972).

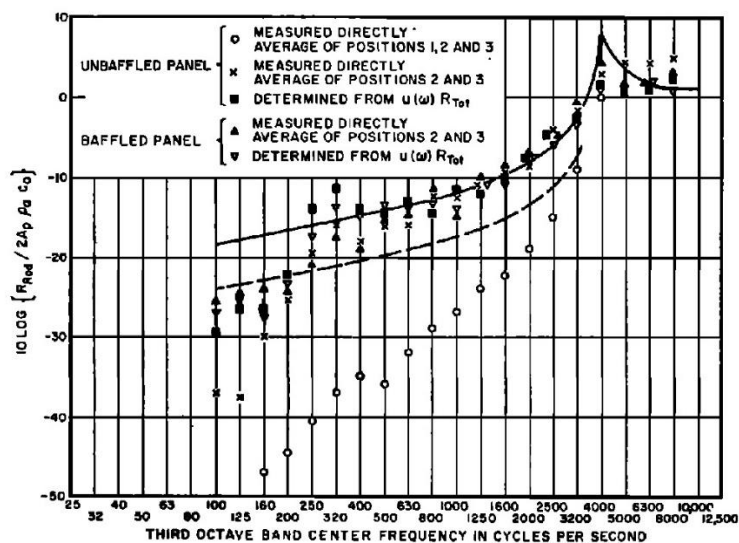
<sup>8</sup>A. Berry, J.-L. Guyader, and J. Nicolas, "A general formulation for the sound radiation from rectangular baffled plates with arbitrary boundary conditions," J. Acoust. Soc. Am. **88**, 2792-2802 (1990).

<sup>9</sup>M.C. Gomperts, "Sound Radiation from Baffled, Thin, Rectangular Plates," Acustica **37**, 93-102 (1977)

<sup>10</sup>B. Laulagnet, "Sound radiation by a simply supported unbaffled plate," J. Acoust. Soc. Am. **103**, 2451-2462 (1998).

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Maidanik's experimental results for the normalized radiation resistance of test panels. Theoretical curves for the baffled unbaffled panel (dash line) and for the baffled ribbed panel (full line). [Reprinted with permission from G. Maidanik, J. Acoust. Soc. Am. **34**, 809-826 (1962). Copyright 1962 Acoustical Society of America (Ref. 1).