Analyzing Generation Mechanism of Specific Echoes whose Frequency Increases Linearly with Time

清原, 健司
Graduate School of Design, Kyushu University

https://doi.org/10.15017/25955

出版情報：九州大学, 2012, 博士（芸術工学）, 論文博士
バージョン：
権利関係：

（様式３）

氏　　名　：清原 健司

論文題名　：Analyzing Generation Mechanism of Specific Echoes whose Frequency Increases Linearly with Time
（周波数が時間に比例して上昇する反射音の生成機構解明に関する研究）

区　　分　：乙

論 文 内 容 の 要 旨

A new, interesting acoustical phenomenon is described, and its generation mechanism is investigated theoretically. When we clap hands once between parallel, hard walls, we hear a sound called a ‘‘fluttering echo.’’ A single hand clap sound (i.e., an impulsive sound) is reflected by the walls repeatedly, and a train of pulses with periodic intervals is generated. This pulse train causes a specific sound sensation; that is, a fluttering echo.

In the fluttering echo, reflected sounds go forward and backward in a one-dimensional pattern between parallel hard walls. What happens, then, when we clap hands in a three-dimensional reflective space? The author found that sweep sound (Audio illustrations are available at: http://www.asp.c.dendai.ac.jp/sweep/) which the author calls ‘‘sweeping echoes,’’ were perceived when we generated a pulse sound in a regularly shaped reverberation room. The perceived frequencies of the sweep sounds increased with time at different speeds. An example of sweeping echoes observed in a rectangular reverberation room is first described. Then, the mechanism that generated the sweeping echoes is investigated by assuming a cubic room and using number theory. The reflected pulse sound train is found to have almost equal intervals between pulses on the squared-time axis. This regularity of arrival times of the reflected pulse sounds is shown to generate the sweeping echoes. Computer simulation of room acoustics shows good agreement with theoretical results.

The ISO allows rectangular reverberation room because of its lower construction cost and easiness of measurement. Also Japanese Industrial Standard (JIS) recently allowed the rectangular shaped reverberation room as TYPE II room. However, the sweeping echoes might interfere acoustical measurements. This paper also discusses adequate volume of reverberation room.

Next, the author investigated sweeping echoes in a two-dimensional (2D) space. The author first describes the investigation of a square cross-section based on number theory. Next, the author describes rectangular cross-section with various aspect ratio investigated based on the same theory as that for the square. The author also discusses the measurements of sweeping echoes in a long hallway. The author propose a method for extracting sweep rates of sweeping echoes by calculating their correlation with a time stretched pulse. The author analyzed the sweeping echoes for a source and receiver at the center of a rectangular cross-section.