Room Dimensions for Optimum Listening and the Half-Room Principle*

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Summary—This paper discusses the relation of room dimensions and speaker placement to the quality of low-frequency sound reproduction. Dimensional ratios for home music rooms are suggested.

APPARENTLY, based on experience, the diagonal D of Fig. 1 represents about the maximum wavelength which can be propagated into a room. Thus, with a speaker system known to exhibit good remaining efficiency down to 30 cycles, the playback of a live pipe organ recording (original tape) gives full response in a room with a 32-foot diagonal.[1] If the room is smaller, the lower part of the bottom octave is weakened. The difference in performance in a room 16×16 feet and one 16×25 feet was evident immediately. The 16×16 diagonal is not quite 23 feet; the 16×25 diagonal is nearly 30 feet. Some slight difference requiring the Figs. 1 and 2 listening test may be considered as marginal, but the difference in the two rooms was well above any liminal level. The rooms had the same treatment, mastic tile on concrete floor with celotex walls and ceiling, and 12-foot ceiling height in each case.

Several conclusions are to be drawn.

1) In designing a new house, the music room should be planned with a 32-foot diagonal, or as nearly that minimum as expedient. It is suggested that the ancient "golden mean ratio" apply with, for example, a length of 27 feet, width of 17 feet, and height of 10 feet, or some reasonable and feasible approach to those figures as in Fig. 3. This "room" is based on ratios of 0.618:1.00; the golden mean ratio is the limit of the ratio of adjacent terms in the Fibonacci series. The application for either single speaker or stereophonic would be good in a room of this size and shape.

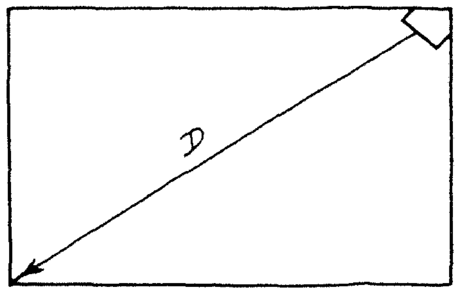

Fig. 1.

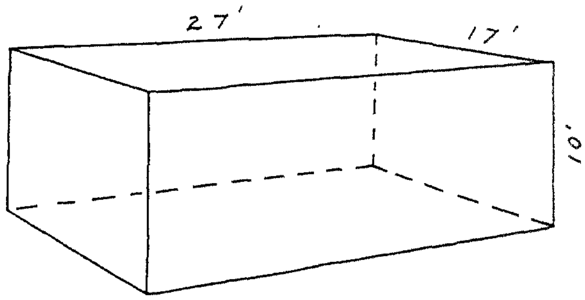

Fig. 2.

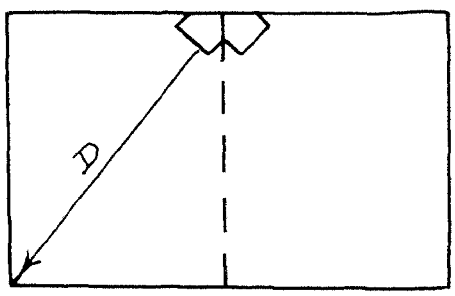

Fig. 3.

2) This brings up an interesting idea about noncorner speakers. Suppose a noncorner speaker is constructed by placing two corner-type speakers back to back against a wall in "free space," as in Fig. 2. This would be equivalent to a single corner unit in a corner, a fact which becomes obvious if one studies the mirror image principle. But in a room of a given size, the wall placement of a pair of corner speakers bisects the room; a wall along the dotted line would create a mirror image dispensing with the need of the second speaker, but the room would be half as large. Based on the 32-foot minimum diagonal thesis, the bass response for the two speakers as in Fig. 2 would be less than for the single speaker in Fig. 1.

Such is actually the case, based on experiment. In fact, the idea was extended to four corner speakers clustered in the center of a room, and the sound was not as satisfactory as for a single speaker system in the natural corner.

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[1] Some large pipe organs have 32- and even 64-foot "stops" representing pipes speaking at fundamental pitches of 16 and 8 cycles per second. Analyses of sound from these pipes show that the radiation is all in the partials or overtones. Ability of a speaker to reproduce uniformly down to 32.7 cycles will suffice to reproduce any pipe organ we have ever recorded.

This shows first that the wall speaker, even if intrinsically full range, is not as good as it would be if placed in a corner, and second, that it takes twice as much speaker for wall use as for corner use, and the response is less in spite of the doubled cost.

The immediate, simple, obvious, and conclusive inference is that any type speaker other than a corner type, and any placement other than in a natural corner, is a costly sacrifice.

Therefore, the design of new homes should be based on provision of corners for speakers, and the application of existing rooms for wide-range sound reproduction should be based on the use of corners even at the expense of remodeling if necessary.

3) The proposed minimum room dimensions and idealized proportions need not interfere with planning relative to nonparallel surfaces, Boner polycylindric treatment of walls, and other factors involving echo breakup and reverberation time. In fact, the liveness is a factor to be considered separately.

4) For the growing interest in stereophonic sound reproduction, it may be said the same principles apply. Experience shows that for the ideal $10 \times 17 \times 27$-foot room [see 1)], the speakers for a two-channel stereophonic array should be placed at the opposite corners on the 27-foot wall.[2] Some lay remarks to the contrary notwithstanding, it has been found that systems designed for narrow spacing and wall placement were always improved by spacing the speakers to the corners, and further improved by substitution of speakers designed for corner application. Adding a third channel in the middle of the wall by mixing the two sound tracks has been found to provide a further improvement in stereo playback,[3] especially when used with corner speaker placement against the *long* wall of the room.

5) Acceptability for homes of Boner polycylindrical surfaces[4] may not be universal, but where good sound is a major consideration, such surfaces are recommended. One room $10 \times 15 \times 26$ feet, built as a studio, was helped considerably by including 300 square feet of such surfaces to aid liveness while using rugs and drapes to offset slap from parallel surfaces.

[2] P. W. Klipsch, "Experiences in stereophony," *Audio*, vol. 39, pp. 16–17, 41; July, 1955.
——, "Making stereophonic tapes," *Music at Home*, vol. 2, pp. 54–56, 68, 72; November–December, 1955.
[3] P. W. Klipsch, "Two track 3-channel stereo," *Audiocraft*, vol. 2, pp. 26–27, 45–48; November, 1957, and vol. 3, p. 37; January, 1958. Also see, "Stereophonic sound with two tracks, three channels by means of a phantom circuit," *J. Audio Eng. Soc.*; April, 1958.
[4] C. P. Boner, "Performance of broadcast studios designed with convex surfaces of plywood," *J. Acoust. Soc. Amer.*, vol. 13, pp. 244–247; January, 1942.

Permanent Magnets in Audio Devices*

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Summary—**The permanent magnet is considered as a component for changing the form of energy. A brief review of the basic physics of the permanent magnet is included with emphasis on the nature of the magnetization process and how the permanent magnet functions in establishing external magnetic field energy.**

Presently available characteristics of permanent magnets and future possibilities for improving the efficiency of the permanent magnet are discussed as well as the relationships between audio device performance and the unit properties of permanent magnets.

In using the permanent magnet the choice of unit properties, volume, geometry, and magnetic circuit arrangement greatly influence the end performance and efficiency of audio devices. As an aid in exploiting the optimum combination of these variables, an electrical analog system using lumped constants is introduced. Data on leakage permeance are presented for the more widely used permanent magnet arrangements in audio work. The analog technique is of general interest from the viewpoint of understanding the energy relationships involved in the efficient application of the permanent magnet and as an aid in predicting permanent magnet performance on a firm engineering basis.

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Introduction

PERMANENT magnets find wide application in audio devices in which a magnetic field serves as the medium of energy transformation in the transformation of electrical energy to mechanical energy and also in changing mechanical energy to electrical energy. As a key component in these devices the permanent magnet influences the efficiency, physical size, and cost. The purpose of this paper is to describe the permanent magnet as a basic system for establishing field energy and to show how permanent magnet properties influence audio device performance. Presently available permanent magnet materials and future possibilities are