Response to "Comments on 'Reducing seat dip attenuation'" [J. Acoust. Soc. Am. 110, xxx–xxx (2001)]

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This letter responds to Klepper's comments [J. Acoust. Soc. Am. **110**, ■■■–■■■ (2001)] on the subject paper, which is concerned with ameliorating seat dip attenuation in auditoria by introducing a pit under the seats. Klepper asks what the effect of the pit will be on seat absorption and reverberation times. A little evidence is presented to support the idea that low-frequency absorption in an auditorium will increase with a pit. It is further speculated that reverberation times could be predicted by using a coupled space model. Klepper's suggestion of an experiment to answer his questions is supported. [DOI: 10.1121/1.1392382]

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I. INTRODUCTION

In the subject paper[1] Davies and Cox investigated early scattered sound from seats as a cause of seat dip attenuation in auditoria. To reduce the attenuation they propose a scheme for modifying the scattered sound by introducing a pit or well under the seats. In his comments on this paper, Klepper asks three interesting questions about the practical effects of such a pit. The three questions are concerned with the effect that the pit might have on audience absorption and the prediction of reverberation time. One of us has some experience in measuring seating absorption,[2] and we offer some tentative responses to Klepper's questions in what follows.

II. EFFECT OF THE PIT ON SEATING ABSORPTION

The pit works by altering the phase of some of the scattered sound from the seats and floor, so that destructive interference is reduced at the listener's head. It is not intended to act as a low-frequency absorber. It seems quite possible, however, that the low-frequency absorption in the auditorium will be increased. If there is a grill over the pit (to support the seats) then the assembly may act as a Helmholtz resonator and this is likely to increase the random incidence absorption at low frequencies. In another scheme for reducing seat dip attenuation, due to Ando *et al.*,[3] devices are introduced into the floor which are specifically intended to be Helmholtz absorbers. One way of achieving this would be to use a ventilation system with small outlet boxes set into the floor between the seats. This has been tried in the laboratory and it was found[4] that the outlet boxes did increase the random-incidence absorption of unoccupied padded seating, as Fig. 1 shows. The resonant frequency of each box was calculated to be 249 Hz. (This measurement was performed in a chamber which was not very diffuse, so the data should be regarded as approximate, especially at low frequencies.)

III. EFFECT OF THE PIT ON RT PREDICTION

Klepper's other two questions relate to reverberation time (RT) prediction. We have no experimental evidence to cite for these, but it does seem likely that the pit is going to play a part in the reverberant sound field, at least at low frequencies. This might be modeled simply by treating the pit and the auditorium as coupled spaces, though the coupling coefficient will probably depend on frequency. In this model, the seats would not be treated as objects in the midst of a volume. Instead, they would lie on the boundary of each space and we would need absorption coefficients for sound incident on the underside of the seats to calculate the reverberant field in the pit. (One possible drawback here is that this concept would seem to further complicate the current debate on auditory spaciousness in auditoria—the listener is now surrounded by sound from below as well!) In any case,it would seem sensible to measure the absorption of some seats with a pit in a reverberation chamber before the hall design is finalized.

IV. CONCLUSION

None of the preceding speculation really provides an adequate answer to Klepper's questions, and we would be

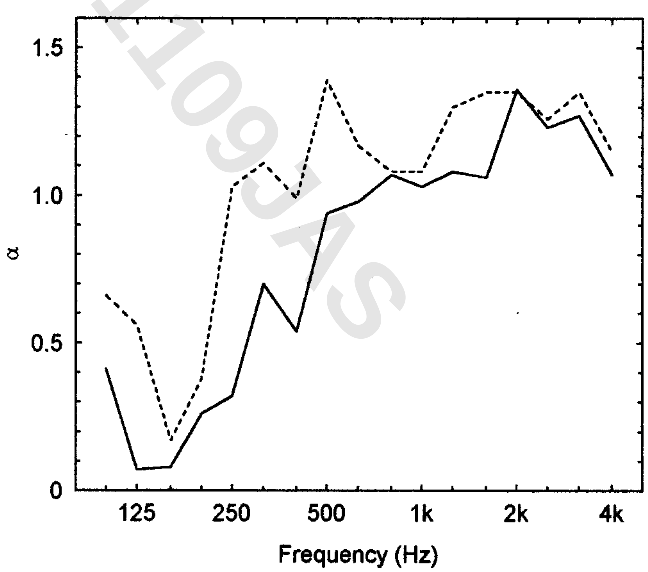

FIG. 1. Absorption coefficient of unoccupied well-upholstered seats on wooden floor. Three rows of six seats were placed in the corner of the chamber with 1-m row spacing and the front and side of the array left exposed. --- Floor ducts exposed; ——— floor ducts covered.

very pleased if an experiment were conducted (either at full scale or in a scale model) to investigate further. We would welcome any opportunity to be involved with such an experiment.

ACKNOWLEDGMENT

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[1] W. J. Davies and T. J. Cox, ''Reducing seat dip attenuation,'' J. Acoust. Soc. Am. **108**, 2211–2218 (2000).
[2] W. J. Davies, R. J. Orlowski, and Y. W. Lam, ''Measuring auditorium seat absorption,'' J. Acoust. Soc. Am. **96**, 879–888 (1994).
[3] Y. Ando, M. Takaishi, and K. Tada, ''Calculations of the sound transmission over theater seats and methods for its improvement in the low-frequency range,'' J. Acoust. Soc. Am. **72**, 443–448 (1982).
[4] W. J. Davies, ''The Effects of Seating on the Acoustics of Auditoria,'' Ph.D. thesis, Salford University (1992).

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