wave in 50 ms travelling at 340 m/s.

2) The reflected sound should have sound energy at least 10% of the direct sound.

The following diagram shows the critical dimensions

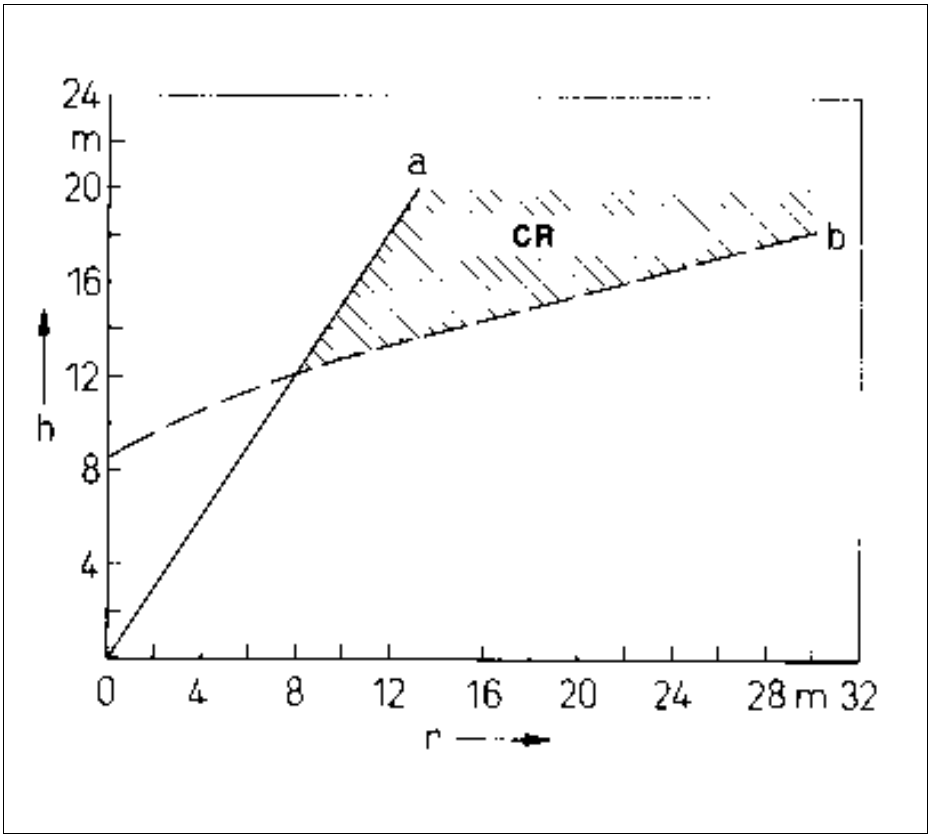

Fig 2 (Source Ref 1, p. 120.) CR = Critical Region, r, x - axis, source-receiver distance, h, y-axis, effective ceiling height

Ray tracing is a very common technique for investigating the behaviour of reflectors and an example is shown below

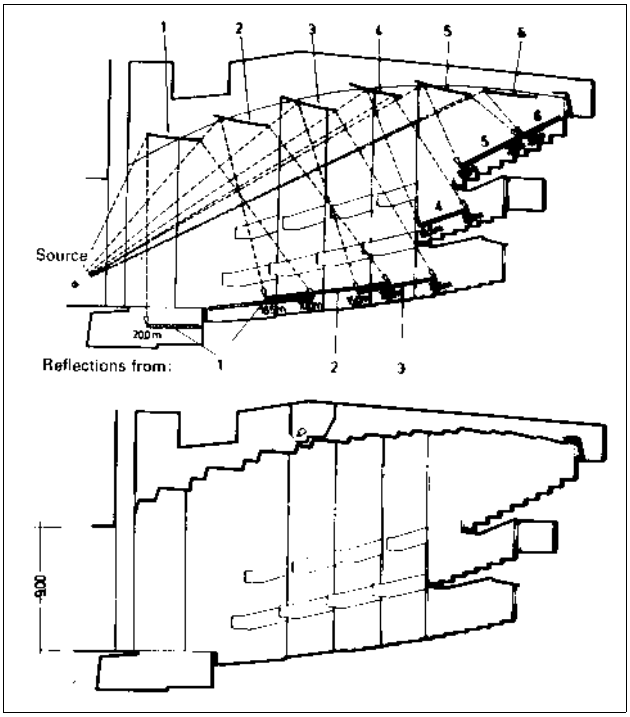

Fig 3 (Source ref 1, p 125) Ceiling profile for the German Opera in Berlin. Top: proposal based on ray construction. Bottom: ceiling as built (architect, Bornemann: acoustic consultants, Cremer and Gabler)

Elliptical shapes need very special consideration. It is vitally important that no source of sound is located near either of the foci as these will be focussed at the other focus. They are best avoided but are a common architectural form.

In general the areas that need attention for echoes in theatres and concert halls are the rear wall, particularly the intersection of ceiling and rear wall and balcony fronts. This may be achieved by the use of absorber or correct orientation of the surfaces.

Reflectors are often used in theatres and concert halls either to increase early reflections to parts of the seating area which are some distance from the source or more particularly in concert halls to increase diffusion. Care must be paid to the size of the reflector as small reflectors will not reflect low frequency sound (due to diffraction effects) and the reflection does not become fully specular until the dimensions of the reflector are several times larger than the wavelength of the sound.

Ringing and colouration are a phenomenon in small rooms that are caused by flutter echoes and standing waves. Some acousticians will argue that these are essentially the same phenomena but it is easier to treat them separately.
A flutter echo is caused by repeated echo between two hard parallel surfaces and is most clearly noticeable when the surfaces in the other dimensions are absorbing. Where the dimension of the space is small these appear as a ring but with larger dimensions can appear like (subdued) rapid machine gun fire. They can be cured by treating one of the surfaces with absorber or where this could cause an unacceptable loss in reverberation such as in a recording studio by building the walls out of parallel- an early acoustic version of deconstructivism.