- *A vocal or instrumental component of a "middle of the band" musical recording*. If the customer decides to listen to music, the requirement is for comparably good, preferably identical performance from all loudspeakers. Dipoles don't have it.

18.4.4 The Perfect Surround Loudspeaker?

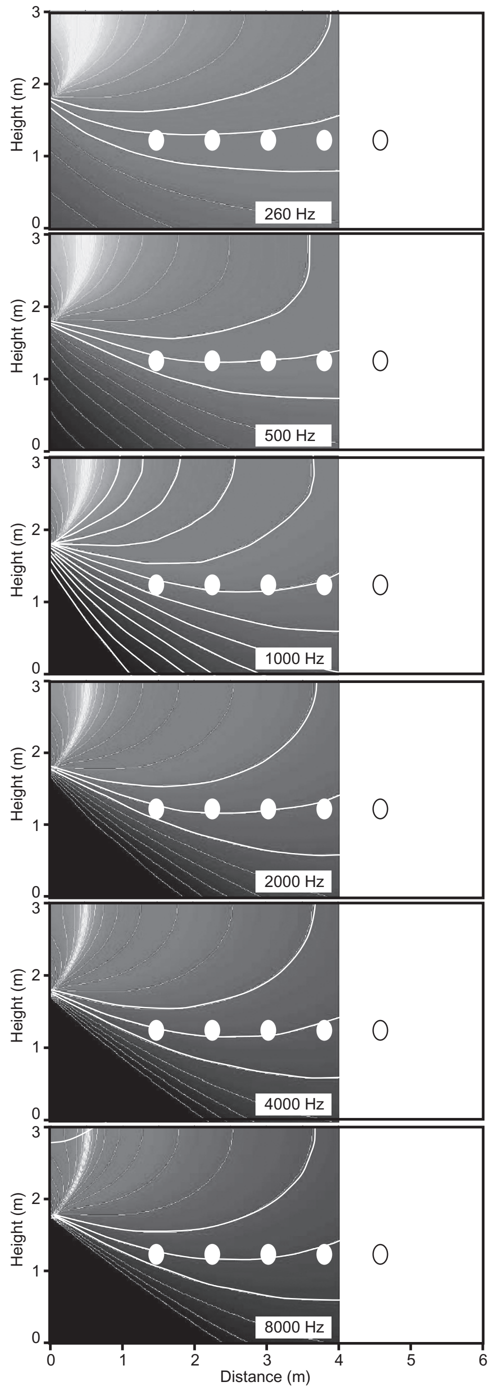
A very wide, uniform horizontal directivity pattern is needed to provide the localization cues for directed sound effects and to establish the basis for the perception of envelopment. Conventional forward firing or bidirectional in-phase on-wall loudspeakers are eminently capable of delivering those experiences, but excellence is guaranteed only for the central seating area. As listeners move toward the sides, sounds arriving from the nearer loudspeaker get rapidly louder, and those from the opposite loudspeaker get quieter. The sense of envelopment is progressively diminished, and it eventually disappears, replaced by sound emerging from the nearby loudspeaker. Figure 16.8 explains the cause—propagation loss—and proposes one solution: full-height line-source loudspeakers. However, as good as they may be, for reasons of size and cost they are not practical solutions for the mass market. A target performance for "the perfect surround" loudspeaker was also proposed: a loudspeaker with, in effect, no propagation loss.

Figure 18.3 showed sound-level contour plots for several variations of truncated, curved, and shaded-line loudspeakers. The two on the bottom (e and f), versions of the constant beamwidth transducers (CBT), were of special interest because they exhibited constant directivity (potentially good sound), and some of the contours held nearly the same sound level over long distances. Inspired by this, Figure 18.21 shows a family of contours taken from the same paper (Keele and Button, 2005) but inverted, placing the loudspeaker at the ceiling interface. The row of "heads" across the width of this imagined room intersect with only one line; they are at a nearly constant sound level from 200 Hz to 8 kHz. And as one moves even closer to the loudspeaker, at the same height, the sound level goes *down*.

There is a leap of faith required in this because the Keele and Button simulations involved only a single horizontal surface, the floor in Figure 18.3, or the ceiling in this inverted diagram. A modified solution needs to include, at the very least, a side wall. Note that sound levels drop rapidly below head level, so the floor reflection is not a factor. Incidentally, these are true line source configurations in that the transducers are small and densely packed. The narrow horizontal profile allows for a very wide and uniform horizontal dispersion.

If a variation of this design, or something else entirely, can come close to this performance target in a real room, the result would be a remarkable improvement in spatial and directional effects for the entire room. It is probable that fewer surround loudspeakers would be needed for large audiences. Whatever may happen, significant degradations from this idealized picture are possible

FIGURE 18.21
Data from Keele and Button (2005) showing a constant beamwidth transducer (CBT) inverted to simulate a surround loudspeaker, showing sound levels as they might be at several listening locations. This simplistic illustration ignores the fact that in reality there is a wall behind the loudspeaker, which was not part of the Keele and Button simulations. A real loudspeaker for this application would need to be modified to accommodate this constraint. The white lines are contours of equal sound level and adjacent lines differ by 3 dB.



before we are worse off than we are now with our conventional, spherical-spreading, small-box loudspeakers.

18.4.5 Equalizing the Surround Channels

It began with the THX "timbre matching" feature, initially justified on the basis that the timbre of a surround channel did not match that of a front-channel loudspeaker. Section 15.6.1 discusses the topic, but the data in Figure 18.20 add to the argument, confirming three things:

- First, if the surround loudspeakers are of the "dipole" configuration, there is absolutely no doubt that the timbres don't match, nor could they possibly do so with such radical differences in acoustical performance.
- Second, the differences among these loudspeakers indicate that no single equalization curve could satisfy all "dipole" loudspeakers.
- Third, equalization can change frequency response, spectrum, and the differences among these loudspeakers and, between any of them and a front-channel loudspeaker, include directivity as well as spectrum. Equalization cannot change directivity or neutralize the timbre of its non-minimum-phase reflected sound field.

Recently, another issue has surfaced relating to the behavior of the phantom image in transition from front to surround loudspeakers (±30° to ±110°). Corey and Woszczyk (2002) examined this situation. When phantom images were placed to the side, some listeners reported split images, with frequencies greater than about 1500 Hz being localized near the front loudspeaker and lower frequencies localized to the side or rear. In spite of this, when asked, listeners responded with a single directional response. Split images are commonplace, and human perception has learned to deal with it, usually with what could be described as "compromise localizations." The analysis of multiple images in sound localization, as it happens, was part of the author's PhD thesis work (see Sayers and Toole, 1964; Toole and Sayers, 1965a, 1965b).

Looking again at Figure 7.6, which shows directional loudness in the horizontal plane, and comparing what the perceived spectral trends are at ±30° and at ±110°, it can be seen that at ±30° the high frequencies are slightly louder than the lower frequencies, and at ±110°, the reverse is true, with lower frequencies appearing to be louder. This pattern supports the listeners' descriptions of the split images when they chose to pay attention to them, which, for the most part, they did not.

It seems there isn't a serious problem, but if one wished to polish the performance of these intermediately localized phantom images, the correct remedy would be to provide for the spectral modifications in the recorded sound tracks,