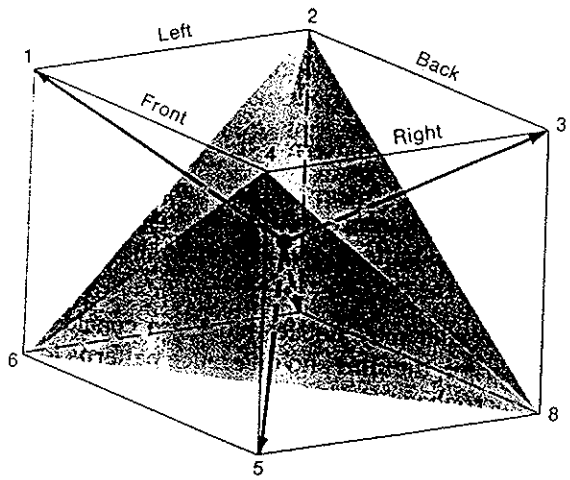
The Soundfield Microphone

Although the sensitivity of a single directional microphone varies as a function of the angle of the arriving sound, that sensitivity may of course represent a signal arriving from the left or right, or from above or below the zero-degree axis. The stereo microphone systems represent a significant improvement by providing a good left-to-right reproduction of the sound field, at the obvious cost of requiring two signal channels. To further improve the recording and reproduction of the complete spherical sound field, it might be argued that an infinity of channels are required, were it not for the obvious physical—to say nothing of financial—constraints.

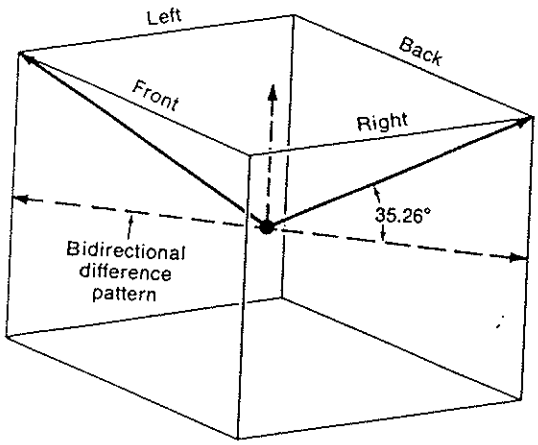
As an alternative to an unrealistic number of signal channels, the Soundfield Microphone System utilizes four separate-but-identical unidirectional capsules placed within a single housing. The microphone is part of the Ambisonic Surround Sound System developed in the United Kingdom under the auspices of the NRDC (National Research Development Corporation). Although a fully implemented Ambisonic system requires four loudspeakers, the system is also used to great advantage with nothing more than a traditional two-channel reproduction system, as described here.

The orientation of the four capsules might best be illustrated by visualizing a geometric construction in which a small regular tetrahedron—a three-sided pyramid—is placed inside an imaginary cube, as shown in Figure 4-18. Note that the vertices of the tetrahedron touch the even-numbered corners of the cube. If a microphone capsule is placed at the center of each surface on the tetrahedron, it therefore points to one of the odd-numbered corners of the cube. In the illustration, these are

1. Left-front up
3. Right-back up



(A) The four subcardioid microphone capsules mounted on the four surfaces of a regular tetrahedron, pointing into four corners of a room.



(B) Detail view of the orientation of the two upward-oriented capsules. The figure-8 difference pattern points front-left to back-right.

Figure 4-18. The Soundfield microphone layout.

5. Right-front down
7. Left-back down

If the tetrahedron is now suspended at the center of a square room, it follows that each microphone will point to a corner of that room, as also shown in Figure 4-18.

A-Format Outputs

By itself, each capsule produces a subcardioid output; that is, a pattern that lies somewhere between a perfect cardioid and an omnidirectional pattern. These four outputs are referred to as the system's *A-format* outputs. The polar equation is $0.667 + 0.334 \cos \theta$ (Farrar 1977), and for comparison purposes it was included in Table 3-1 in the previous chapter. However, the power of the Soundfield microphone is not in the individual output of a single capsule, but in the infinite variety of outputs made possible by various capsule combinations.

So far, we have learned that

- When any two unidirectional patterns are combined, the resultant difference pattern is oriented at 90 degrees to the axis of the sum pattern (see Figure 4-17).
- When any two unidirectional patterns are subtracted, the resultant pattern is always bidirectional (see page 140).
- When any two unidirectional microphones are placed back to back and their patterns are summed, the result is always omnidirectional (see page 140).

With these points in mind, consider the two subcardioid capsules pointed at the left-front and right-back upper corners. Their figure-8 difference pattern is horizontally oriented on a diagonal between the left-front and right-back of the room, as shown in the detail view in Figure 4-18B. It follows that other subcardioid combinations will produce still other bidirectional patterns at other orientations. Table 4-3A lists four such orientations when *A*-format outputs are combined.

B-Format Outputs

If the combinations seen in Table 4-3A are again combined, the resultant signals are the *B-format* outputs listed in Table 4-3B, which are identified by the letters *W*, *X*, *Y*, and *Z*.

If the derivation of the omnidirectional pattern is unclear, just note that the summation of *any* two *A*-format patterns produces a unidirectional pattern; the summation of the other two produces the same pattern but oriented 180 degrees to the first one; and the summation of any two identical back-to-back patterns is always an omnidirectional pattern. Further combinations of the four *B*-format signals will create just about any polar pattern and orientation required, with a few typical examples listed in Table 4-3C.

The Soundfield microphone system is seen in Figure 4-19, along with the control unit used to process the outputs. By varying the relationship between the *W* signal and the other three, any polar pattern between omnidirectional and bidirectional may be selected, and the resultant pattern may be oriented left, right, up, or down. Two such patterns may be fed to the control unit's stereo output jacks, or all four *B*-format signals may be routed directly to a four-channel tape recorder for stereo processing after the recording session.

Table 4-3. Soundfield Microphone Outputs

(A) Subtraction of A-Format Outputs

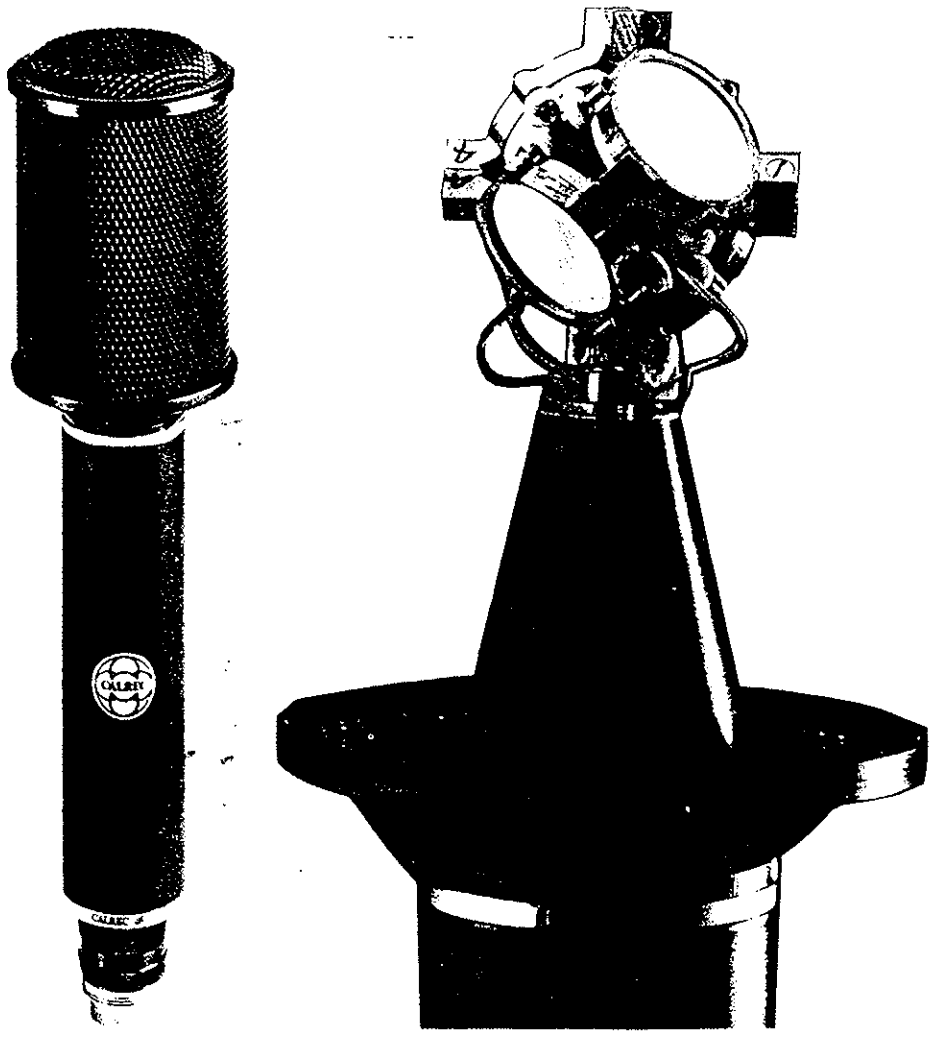
***A*-Format Combinations**	**Resultant Output Is a Bidirectional Pattern Oriented**	
	From	*To*
1–3	left-front center	right-back center
5–7	right-front center	left-back center
1–7	center-front up	center-back down
3–5	center-back up	center-front down

(B) B-Format Signals

Capsule Combinations	**Polar Pattern**	**Pattern Orientation**	***B*-Format Signal**
(1 + 3) + (5 + 7)	omnidirectional		*W*
(1 − 3) + (5 − 7)	bidirectional	front-to-back	*X*
(1 − 3) − (5 − 7)	bidirectional	left-to-right	*Y*
(1 − 7) + (3 − 5)	bidirectional	up-to-down	*Z*

(C) A Few B-Format Combinations

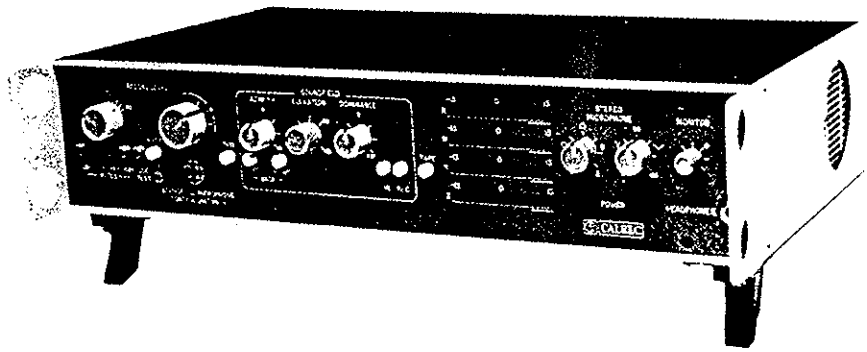
***B*-Format Combinations**	**Polar Pattern**	**Pattern Orientation**
W + *X*	cardioid	forward
W − *X*	cardioid	rearward
W + *X* + *Y*	cardioid	45° left-of-center
W + *X* − *Y*	cardioid	45° right-of-center



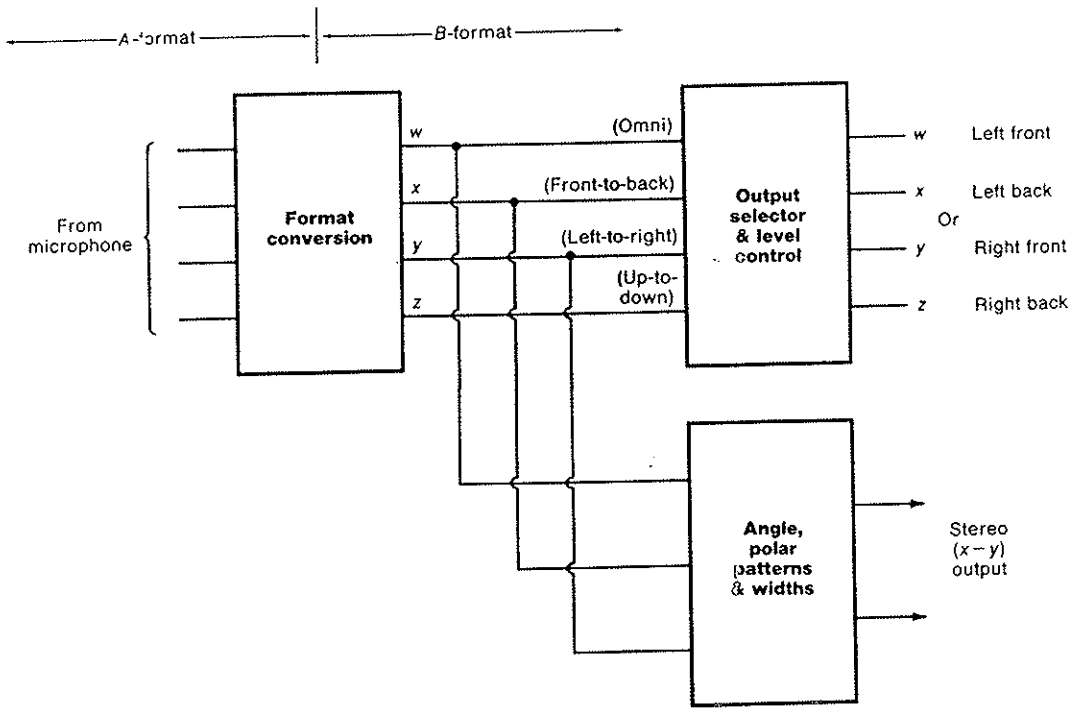
(A) Microphone. (Courtesy AMS/Calrec, USA)

(B) Detail view of its four-capsule assembly. (Courtesy AMS/Calrec, USA)

Figure 4-19. The Soundfield Microphone System. *(continued on next page)*



(C) Control unit used to process the A-format outputs received from the microphone. (Courtesy AMS/Calrec, USA)



(D) Simplified block diagram of the Soundfield control system.

Figure 4-19 *(continued)*

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