BENJAMIN B. BAUER

The Ghent Microphone System

Using a combination of 100 degrees and two 80 degree side pickups, the system employs both stereo and matrixed quad.

MICROPHONE TECHNIQUE for sound pickup in a studio is well established: one microphone (or more) is provided near each performer or group of performers and the outputs are recorded on individual tracks of multi-channel tape. Later, the producer mixes the individual tracks onto a two- or four-channel master tape. Because of the ease of editing and the possibility of adding special effects, this "proximate" multi-microphone technique is almost universally used, especially for popular music.

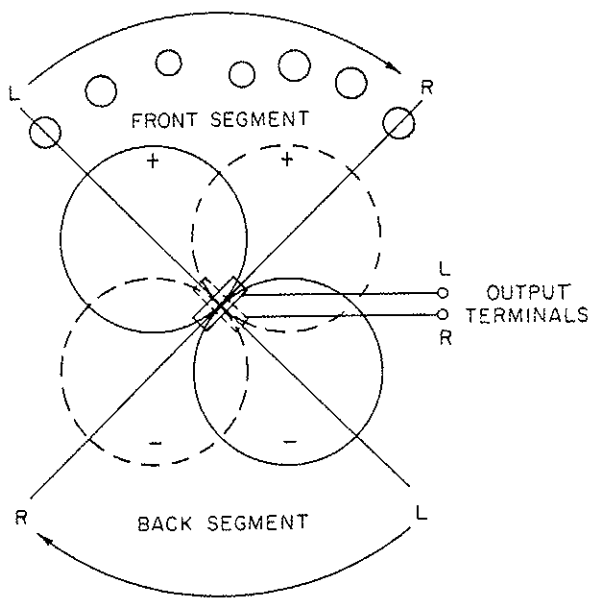
However, there is another, less-frequently-used microphone technique which is most useful in natural settings such as live opera, an orchestral performance in a concert hall, and religious music played in a cathedral. Here, the preservation of the natural hall reverberation, and/or the natural position or motion of the performers, is paramount. In these cases, it is convenient to pick up the performance with an array of microphones clustered around one point in space. Such is the *cross-gradient* microphone system proposed by Alan Dower Blumlein in the early thirties, or the so-called M-S microphone system attributed to Lauridsen and Steinhausen in the fifties. And now, a new "spatial" microphone array is available for this purpose—the CBS Ghent Microphone System, which offers a number of advantages compared with the earlier schemes.

Prior to discussing the details of the Ghent Microphone System, let's briefly review the operation of the older crossed-gradient and M-S systems.

THE CROSSED-GRADIENT SYSTEM

In the cross-gradient system, two velocity transducers are closely placed together and oriented at 90 degrees with respect to each other. The performance is depicted by two crossed figure-eight polar sensitivity patterns, as shown in FIGURE 1. The crossed-gradient system has two useful sound pickup zones comprising the front and the back 90 degree segments. Since in a live pickup situation, as in a concert hall, it is necessary to minimize the audience noise—coughing, etc.—the rear zone is not, as a rule, utilized. The microphone is placed high above the floor and tipped forward, to direct the front quadrant toward the stage and the back quadrant away from the audience. The side quadrant sounds are reproduced anti-phase, which does not lead either to good stereo or good mono sound because the anti-phase signals sound "phasey" in the former mode and are cancelled in the latter. Thus, in a traditional long, rectangular hall, where strong lateral eigentones (resonance frequencies, caused by the room's surfaces—Ed.) are present, the cross gradient microphone causes problems. It can, however, be used successfully in locations which do not exhibit strong lateral reverberant modes—in a semi-circular hall, for example, or in a relatively dead studio, if care is taken to avoid placing the performers in the side quad-

Figure 1. Polar patterns for Blumlein's "Crossed-Gradient" Microphone System.



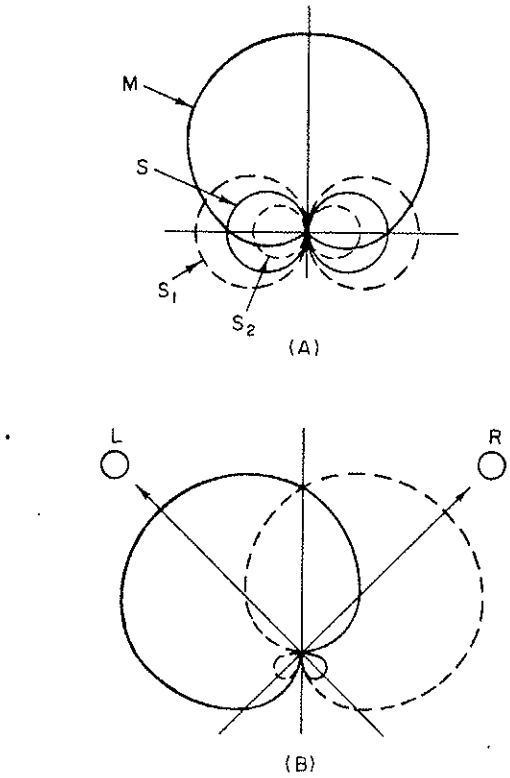


Figure 2. Polar patterns for the M-S Microphone System.

rants. Under these conditions the crossed-gradient microphone can produce excellent stereo sound.

THE M-S SYSTEM

The M-S microphone, shown in FIGURE 2A, uses a "middle" cardioid microphone, M, facing toward the group to be recorded. The output of a "side-oriented" velocity microphone, S, is both added and subtracted to the M output. The summed output produces a right-oriented limaçon, R, while the differenced output produces a left-oriented limaçon, L, as shown in FIGURE 2B. By adjusting the gain of the velocity microphone, S, relative to the cardioid unit (as shown by the broken-line patterns in FIGURE 2A), a variety of patterns may be obtained. When the two output channels are combined, a front-oriented cardioid pattern is created, resulting in reasonably good mono compatibility, although the loudness balance of the directional signals is somewhat altered.

The above M-S microphone configuration has the advantage of operational flexibility and the avoidance of anti-phase pickup. It has the disadvantage of being unable to provide good channel separation over a relatively narrow front-angle—say a quadrant or so—often resulting in center-heavy performance. Other M-S microphone arrangements have been tried in an effort to overcome this problem. One of them, for example, consists of two axially-adjustable limaçon microphones equipped with electrically adjustable polar patterns to provide a variety of directional parameters.

GHENT MICROPHONE SYSTEM

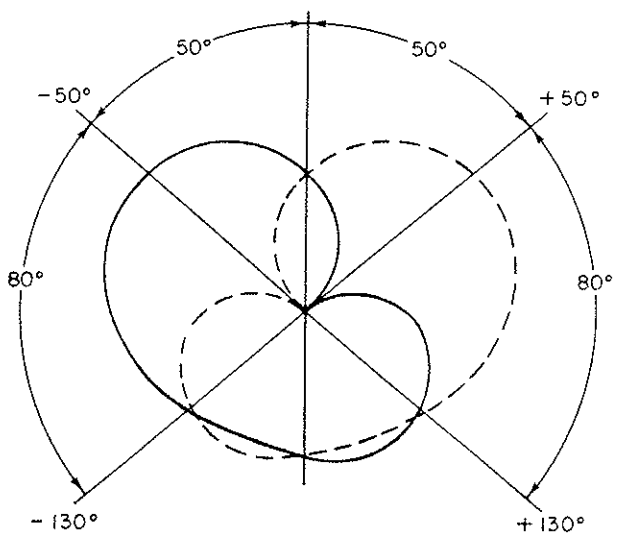
In the conventional stereo mode, the Ghent Microphone System (whose polar patterns are shown in FIGURE 3) picks up the sounds arriving over a 100 degree front angle. The sounds arriving over two 80 degree side segments are encoded in the SQ quadriphonic matrix mode. Thus, the Ghent System serves the dual purpose of picking up the stage sounds in stereo, and the ambiance in surround-sound quad. And, because these sounds are picked up from a single point in space, the actors in, say, a dramatic presentation, or an outdoor street scene, are able to move freely around the frontal 260 degree angle, being automatically properly encoded for stereo or surround-sound quad reproduction depending on their axial location. Exemplary quadro, stereo, and mono-compatible performance is thereby obtained.

While still experimental in nature, the Ghent Microphone System has already been successfully employed in a number of applications. It was used with the BBC Orchestra at the Royal Albert Hall in London, the New York Symphony at Avery Fisher Hall, and the Detroit Orchestra in Michigan. The 1977 season of the Filarmonica de las Americas at the Palacio de Bellas Artes in Mexico City was broadcast using the Ghent System.

A significant advantage the Ghent System shares with the crossed-gradient system is its excellent ±50 degree front-oriented stereo pickup area, which meets the requirements both of stereo and the SQ quadriphonic system specifications. At the ±50 degree positions, a 46 dB channel separation is available, with in-phase center-front sound pickup mode. The 80 degree angular side areas, important in a traditional concert hall, encode the lateral reverberation in the SQ mode, resulting in a broad reverberant energy display when listening either in the stereo or quad modes. The stereo or quad energy pickup is uniform within 0.6 dB all around the compass

The back quadrant retraces the front three-quadrant space, and, therefore is used only in special circumstances. Thus, in order to minimize audience sounds, the Ghent microphone usually is placed quite high above the stage and is oriented downward toward the orchestra, with the back quadrant facing away from the audience, as with the crossed-gradient system. The direct orchestral pickup versus the audience pickup is helped by the relatively "flat" profile

Figure 3. Polar patterns for the SQ Ghent Microphone System.



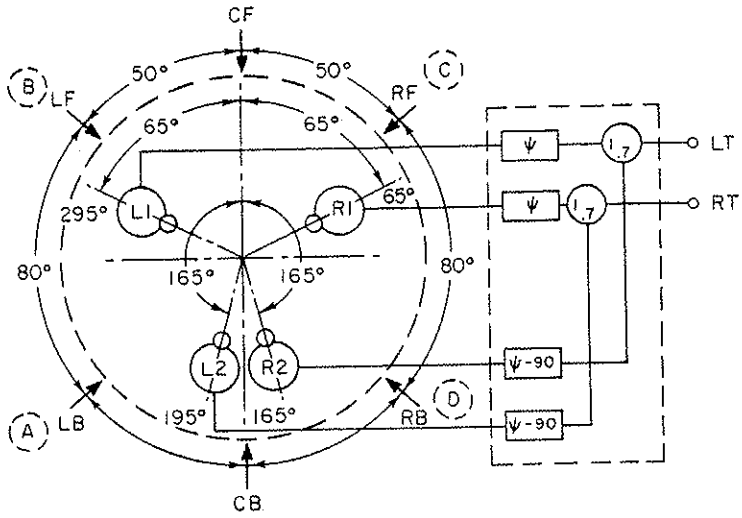


Figure 4. Schematic principle of the Ghent Microphone System.

polar pattern of the Ghent microphone, which follows the super-cardioid law, $0.3+0.7 \cos \theta$.

Directional sounds arriving at ± 130 degrees azimuth from the center front result in output signals which are equal and in phase-quadrature (90 degree ø shift—Ed.)—the left channel output leading for the sounds arriving at −130 degrees and the right channel output leading for sounds arriving at +130 degrees. This is precisely the signal organization required by the SQ code for the left-back and right-back channels, respectively. Played back through an SQ decoder, these signals are decoded in the appropriate left-back and right-back loudspeakers. In the stereo mode they are "folded" and reproduced near to, and at either side, of center. Therefore, as an option, the Ghent System may be placed right in the middle of the orchestra, resulting in good stereo distribution of the instruments in the stereo mode and in a surround-sound display in the quadriphonic mode.

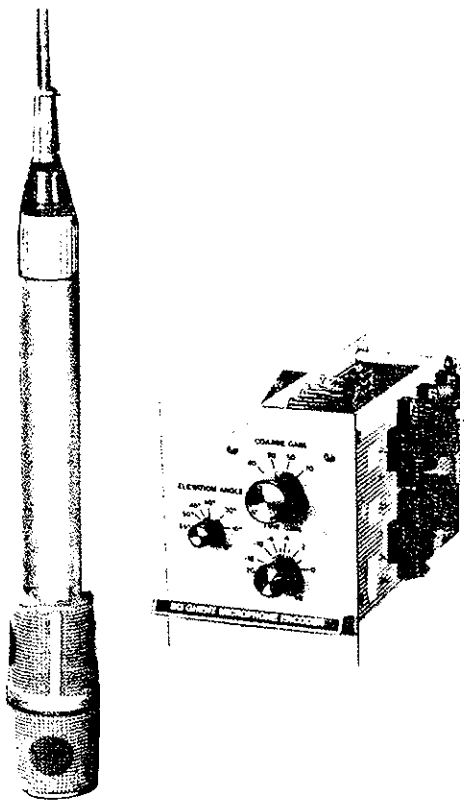
DESIGN DETAILS

The performance achieved with the Ghent Microphone System requires a rather unorthodox microphone confiuration. As shown in FIGURE 4, the microphone array consists of four limaçon-pattern transducers with polar response defined by the equation, $0.3 + 0.7 \cos \theta$, where θ is the angle respecting the axis of maximum sensitivity of each transducer. The four transducers are oriented in space as shown in the left-hand side of the figure, with the two front elements, L1 and R1, being positioned at ±65 degrees, and the two back elements, L2 and R2, being positioned at ±165 degrees, with respect to the 0 degree center-front direction. The four elements actually are vertically coaxial, i.e., the origins of the patterns fall on top of each other. In FIGURE 4 they are shown separated from the center only for clarity.

To complete the Ghent System, a special encoder is needed, shown at the right-hand side enclosed by the broken-line rectangle. The encoder consists of phase-shift networks which are identical to those normally used in a conventional SQ encoder. Specifically, the networks labeled ψ connected to the front transducers have a phase shift which is linear with the log of frequency; those labeled ψ-90 degrees also have a similar phase shift function which, however, is displaced from the first one by −90 degrees (lagging) at all frequencies. The latter networks are connected to the back transducers, and their outputs are multiplied by 0.7 and summed to the outputs of the opposite front transducer's networks to form the combined signs, LT and RT.

The Ghent systems deployed in field tests have been constructed by using basic QM-69 Neumann microphones

Figure 5. The Neumann QM-69 microphone and the special adapter used for the Ghent system.



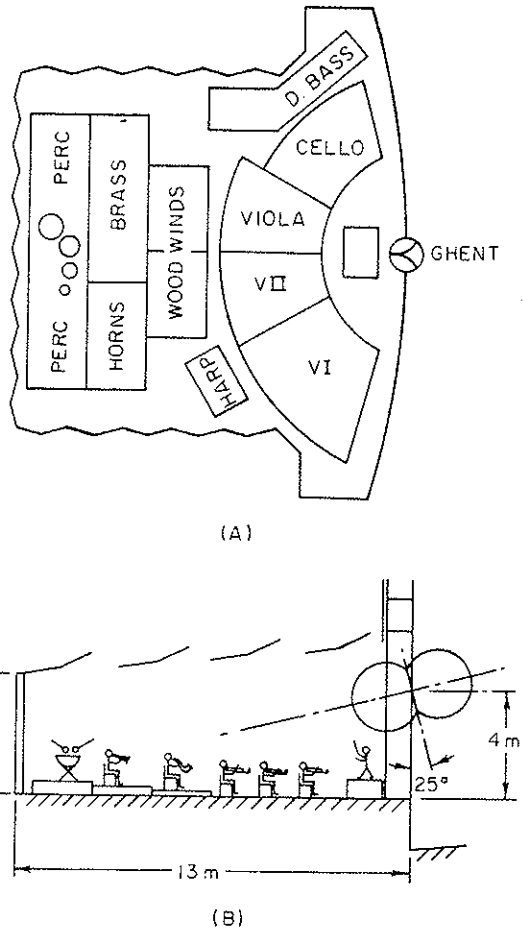


Figure 6. Microphone arrangement for conventional stereo or ambiance quad recording.

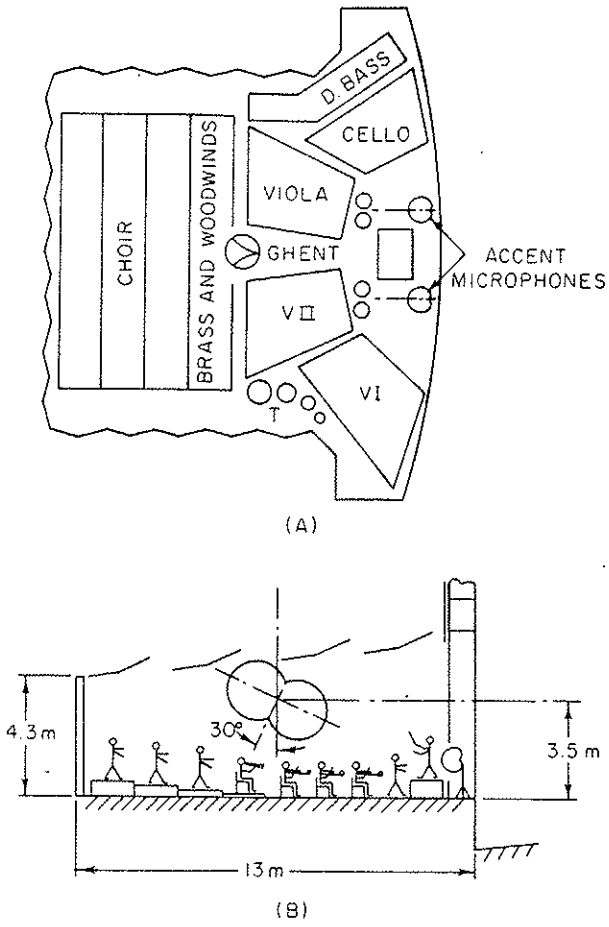


Figure 7. One microphone arrangement for stereo-compatible surround-sound recording.

suitably matrixed to produce the four limaçon patterns shown in FIGURE 4. The QM-69 Neumann microphone, together with the system's special adapter, is shown in FIGURE 5.

To illustrate the most common method of using the Ghent Microphone System, a cross-sectional elevation and plan view of the arrangement used for broadcasting a conventional symphonic performance from the Palacio de Bellas Artes in Mexico City is shown in FIGURE 6. A more adventuresome variation, used with Mozart's *Requiem*, which features a 60-voice choir, is shown in FIGURE 7. Here, the microphone is placed in the middle of the orchestra facing the conductor, inclined to favor the strings and to attenuate the sound of the strong choral group. With the provision of two accent microphones used to pick up the soloists, a well balanced surround-sound performance was obtained, albeit it was necessary to reverse the microphone outputs left for right in order to retain the proper perspective on reproduction.[6] This latter method of sound pickup gave such favorable results that it was used in all the 1978 summer season's symphonic performances broadcast from Bellas Artes.

CONCLUSION

In conclusion, the ongoing experiments with the Ghent Microphone System have shown it to be a powerful tool for the recording engineer. It picks up the orchestral sound with the precision of the Blumlein crossed-gradient microphone, but has the advantage of eliminating the latter's antiphase zones and of encoding the ambiance in a natural SQ quadriphonic mode. It provides an added flexibility for surround-sound orchestral and dramatic performances. It is easily installed and offers a balanced sound transmission for the broadcaster who often is unable to expend much experimental effort for a live broadcasting setup.

Experimental results to date have made it amply evident that the Ghent Microphone System is bound to become an important tool in the practicing audio engineer's bag of tricks. ■

REFERENCES

1. B. B. Bauer, "Quadraphony, Spatial High Fidelity and Compatibility," IEEE Transactions on Broadcasting. Vol. BC-23, pp. 76-84 (Sept. 1977).
2. B. B. Bauer, D. W. Gravereaux, A. J. Gust, "A Compatible Stereo-Quadraphonic (SQ) Record System," J. Audio Eng. Soc., vol. 19, pp. 638-646 (Sept. 1971).
3. B. B. Bauer, G. A. Budelman, D. W. Gravereaux, "Recording Techniques for SQ Matrix Quadraphonic Discs," J. Audio Eng. Soc., vol. 21, pp. 19-26 (Jan/Feb 1973).
4. B. B. Bauer, R. G. Allen, G. A. Budelman, D. W. Gravereaux, "Quadraphonic Matrix Perspective—Advances in SQ Encoding and Decoding Technology," J. Audio Eng. Soc., vol. 21, pp. 342-350 (June 1973).
5. B. B. Bauer, L. A. Abbagnaro, D. W. Gravereaux, and T. J. Marshall, "The Ghent Microphone System for SQ™ Quadraphonic Recording and Broadcasting," J. Audio Eng. Soc., vol. 26, pp. 2-11 (Jan/Feb 1978).
6. B. B. Bauer, G. Cota, "Quadraphonic Broadcasting of the Filarmonica de las Americas in Mexico," J. Audio Eng. Soc., vol. 26, pp. 356-360 (May 1978).