One Approach to Four-Channel Sound—

Dynaco/Gately

Dynaco Quadaptor

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THE SO-CALLED "matrix-process," like the science of engineering, is essentially a compromise, a judicious balancing of one benefit (a particular performance capability) against another (cost). In a word, what matrixing does is to trade *unneeded* amounts of channel separation (left-front to right-front, right-front to right-rear, etc.) for the ability to recover not only hall ambience but a significant degree of the directional potential of four utterly discrete channels *without* rendering our existing equipment unusable. By deliberately manipulating phase and amplitude from four different sources, we can encode two-channel LP, tape, or FM broadcast. The matrix technique, indeed, is the only four-channel approach which can at present be applied to all program sources. The owner of ordinary stereo or mono equipment isn't even aware of the encoding. But if the listener has the needed *decoder,* he can recover controlled and predictable four-channel results.

At present there are two complete encode-decode systems available on an off-the-shelf, production-line basis. Dynaco and Gately Electronics cooperated to produce one, Electro-Voice and Audio Designs collaborated to manufacture the other. As the E-V "Stereo-4" system is discussed elsewhere in this issue, as are two other matrix systems from CBS and Sansui, I'll be more concerned with the Dynaco/Gately approach.

(The Sansui system is available and is in use by a number of broadcasting stations.—Ed.)

Fortunately, the first point to be made is that *these two existing total matrix systems are compatible with each other.* A recording processed by the Gately QE-1 quadraphonic encoder can be decoded by any of the various Electro-Voice-licensed home units; we'll see why shortly. Similarly, Dynaco's Quadaptor playback unit is recommended by *its* manufacturer for use with all "Stereo-4" encoded material.

In order to understand how the whole encode/decode matrixing process works, let's start with the overlaid patterns shown in Fig. 1. (I've used the now-conventional lettering, though differentiating between "right-front" and "center-rear" by merely capitalizing the "B" in the latter case invites confusion.) These patterns, which, if one of them is shifted by 45° become superimposed, may be looked at from two *very* different perspectives. On the one hand they could be seen as approximate playback speaker locations in our listening rooms. Contrariwise, one might view them as at least rough indications for microphone placement at a "live" recording session. One's natural impulse—until you stop to think it through—is that these should be the same, so that if a recording was encoded on the diamond pattern we should have to decode it by putting our "front" speaker in the fireplace and our "back" speaker behind the couch.

Fortunately, this is nonsense, for while the Gately encoder permits the recording engineer to select either a square or a diamond-shaped *encoding* pattern, that choice does *not* dictate the placement configuration of our playback speakers, nor, for that matter, does it affect *our* choice between the E-V or the Dynaco *decoding* systems. To see why this is so, all we have to do is to compare the actual encoding formulas used to encode quadraphonic information by the Gately/Dynaquad and by the Electro-Voice Stereo-4 techniques. So, using the lettering of Fig. 1, here they are:

Gately QE-1, switch set in square position:
Left encoded output: a + 0.25b + c -0.5d
Right encoded output: 0.25a + b -0.5c + d
Electro-Voice Stereo-4 (square only):
Left encoded output: a + 0.3b + c -0.5d
Right encoded output: 0.3a + b -0.5c + d
Gately QE-1, switch set in diamond position and microphones set in the four corners:
Left encoded output: a + 0.5b + c -0.5d
Right encoded output: 0.5a + b -0.5c + d

It takes no mathematician, of course, to see how close are the similarities in these formulas. Comparing the Gately and the Electro-Voice squares the coefficient difference is 0.05—probably less than the tolerance of the resistors used in the input matrixes! Clearly, too, "a + 0.25b" means that on the encoded left-front to right-front, channel separation is 12 dB, exactly what will be reproduced if we don't decode at all, which is, of course, the situation of the ordinary stereo listener. Paradoxically, the recurring "-0.5d" in the formulas does not really mean that we are subtracting the output of the "d" microphone from the contribution of the other three. It means only that the "d" signal is out of phase with the others; the 0.5 means that relative to the "a" or "c" signal strength, the "d" output is 6 dB lower.

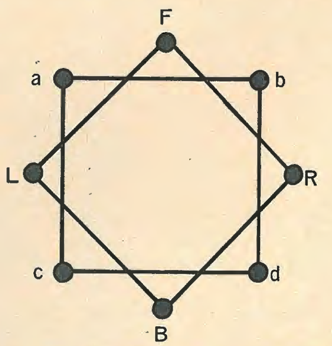

Fig. 1—Speaker relationships of "diamond" and "square" matrixing patterns.

Fig. 2—Gately Electronics' quadraphonic encoder Model QE-1.

Presenting the QE-1 diamond encoding pattern in terms of the 4-corner, a, b, c, and d microphone locations is somewhat misleading. It appears as if what we conventionally think of as "left/right" separation was being reduced to 6 dB (a + 0.5b) when, by throwing the switch into the square configuration we could keep 12 dB (a + 0.25b). Stated in terms of its own lettering diagram in Fig. 1 (a more realistic indication of the placement pattern with which it would be used), the diamond outputs are actually:

Left encoded output: L + F + B
Right encoded output: R + F - B

Here, of course, "left/right" separation is total. The encoding formula I gave earlier redefines the diamond into a square by assuming that F = a + b, L = a + c, R = b + d, and B = c-d. The relative merits and demerits of encoding in the optional diamond pattern provided by the QE-1 will be evident when we see what happens to the encoded signals later.

Except for the very advanced amateur recordist, of course, the entire matrix encoding process lies solely within the province of the professional: the broadcaster or producer of LP's and prerecorded tapes who desires to build quadraphonic information into its normal studio product. The Gately QE-1, therefore, is expressly designed for the studio, from its Cannon XLR connectors to its ability to drive 600 ohm loads at levels up to +24 dBm. But a look into its optional "extras" may give some of us audiophiles an insight into what it is that the pros pay for. The transformerless version "A" pictured in Fig. 2, for example, carries a basic price of only $249.00; version "B," with built-in 600-ohm balanced line output transformers, goes for $299.00. Those studios partial to transformer-coupled inputs will simply remove the dummy plugs provided on the back panel and replace them with standard Ampex plug-in units (either matching or bridging), at a cost of about $80.00. And, if it's desired to monitor the input signal levels at the encoder itself rather than at the recording console, an accessory matching panel with four VU meters is available for $250.00. Adding all these optional features together, we've gone all the way from $249.00 to $629.00! That's quite a jump just for studio transformers and meters, but professional equipment isn't cheap: The E-V encoder lists for $795.00.

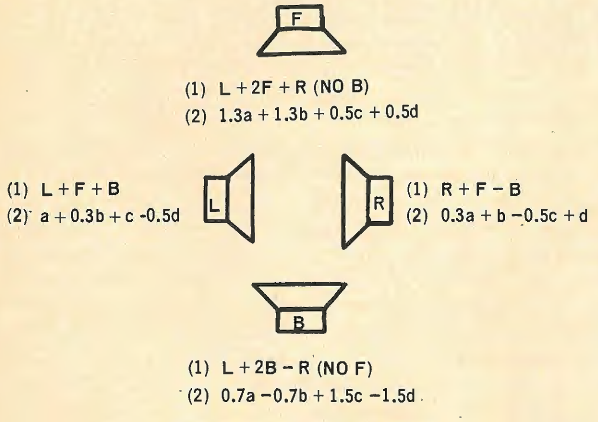

Fig. 3—Dynaco diamond decode, net results: (1) Gately diamond encode, (2) E-V square encode.

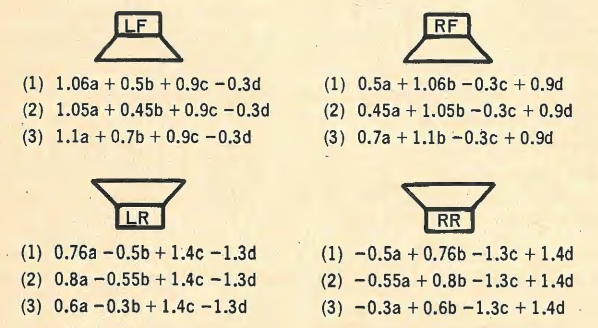

Fig. 4—E-V decoding, net results: (1) E-V square encoding, (2) Gately square encoding, and (3) Gately diamond encoding.

A complete schematic diagram of the QE-1 encoder and a lengthy circuit analysis would be out of place, but the basic unit is built around four integrated circuit operation amplifiers, whose use in a wide variety of audio applications was discussed by Mr. Gately ("The Wonderful World of Integrated Circuits") in the June, 1970 AUDIO*.

Essential though encoding systems are to matrixed quadraphony, however, most of our primary interest centers in what happens when we *decode* the signals and feed them to our speakers. Here the approaches taken by the two total matrix systems diverge more sharply, though they all *work* and on each other's encoded material.

For example, take the very simplest decoding approach, the original Hafler diamond speaker placement. True, it doesn't fit the geometry of very many of our living rooms, and it assumes, too, that we are all using Dynaco amplifiers with their "blend" facility. On the other hand, it requires neither a second stereo amplifier nor even any sort of "quadraphonic adaptor." The basic decoding formula for this approach is that speaker F receives $L_e + R_e$. The left speaker gets L_e alone, and correspondingly the right speaker reproduces only R_e. The back speaker is fed with $L_e - R_e$ (The "e" subscripts simply remind us that it is the *encoded* left and right signals with which we are dealing. The other lettering is the same as in Fig. 1).

What happens when we put the Gately-encoded diamond and the Stereo-4 encoded square into this dematrixing network of speakers is a straight question of algebra, and the results are summarized in Fig. 3. Obviously we get terrific results with the total diamond encoding/decoding approach: left to right side separation is complete, as is center front to back. Nor, however, are we very badly off decoding the E-V square on the diamond configuration. A 0.3:1 ratio for left/right gives us a bit more than 10 dB there, and we get anywhere from about 6 to a little over 8 dB of suppression of unwanted front and back signals from the speakers where we don't want them. Too bad our listening rooms aren't often built like Dave Hafler's!

When we turn to the more familiar 4-square speaker placement (with attendant decoding systems), the differences between the E-V and the Dynaco approaches become more marked. The most obvious one is that the Electro-Voice technique uses two stereo amplifiers, while the Dynaco Quadaptor gets along with the one we already have. An integrated circuit within the Stereo-4 decoder splits the two encoded inputs into four separate preamp-level signals (hence the need for four power-amplifying channels), according to the following formula:

Left-Front = $L_e + 0.2R_e$
Right-Front = $R_e + 0.2L_e$
Left-Rear = $L_e - 0.8R_e$
Right-Rear = $R_e - 0.8L_e$

Figure 4 now summarizes the algebra and indicates what each of the speakers reproduces when fed (1) with the Stereo-

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*See also, by the same author, "I.C.'s, The Coming Revolution," *db*, September, 1970.