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sound

CANADA

LAB REPORTS on the

BOWERS & WILKINS DM-4 LOUDSPEAKER

SUPERIOR 201D CASSETTE DECK

DUAL 1225 TURNTABLE

REVOX A700 STEREO TAPE DECK

In the studio with Seiji Ozawa

How Helen Reddy avoids glamour

A fresh appraisal of Quadriphonics

Kit Robinson

Quadriphonics* revisited

a special sound supplement

Changes come slowly in the audio business. At least, they've been a long time coming in quad.

Just over a year ago, in our last roundup of quadriphonics developments, we wrote: "The picture is still far from settled, but the lines are fairly well drawn."

On that basis, this may read rather like an instant replay.

Although a year is frequently enough time for a new audio trend to make itself felt — or to fade from the scene — the status of four-channel sound is much as it was last year. The two leading systems of 1973 are emerging even more as the leading contenders (and making significant progress towards bringing recorded sound ever closer to live concert sound) while the other systems are fading ever more into oblivion, but the situation has changed remarkably little.

In a sense, we've lived this experience before, when stereophonic sound began to move from the tape recorders of a few well-heeled experimenters into the living rooms of the music listeners equipped with only basic disc playing gear. Just as early stereo had many problems (not the least being the highly exaggerated stereo effect that we labelled the "ping pong" effect after the sound effects recordings that were so popular during that era), much of the recorded material on 4-c discs (particularly the CD-4 discrete discs) needs improvement. And, as it was with stereo, there's every reason to believe that four channel sound will, before very long, be sufficiently low in distortion (and other problems) to become as common as stereo in the seventies.

Readers who studied our discussion last year may recall that, after some deliberation, we settled on the spelling "quadr*i*phonics" instead of the "quadr*a*phonics". Grammatical construction and the Institute of High Fidelity Manufacturers are on our side, instead of the quadr*a*phonics spelling which some firms have adopted. (We've recently noted that some of our English cousins are using the word quadr*o*phonic.)

** The IHFM (Institute of High Fidelity Manufacturers) has adopted the spelling QUADRIPHONIC, despite the widespread use of the less plausible spelling with an "a" in the middle. We will use the "quadriphonic" spelling except when spelling a copyrighted name or phrase.*

Quad Variations

There are still four common methods (including minor variations within some of the four groups) of producing four channel sound in home listening systems.

First – and simplest – is the recovery, by means of a rather simple resistive network circuit applied to the stereo amplifier outputs, of some of the "ambience" (the sounds reflected from the back and sides) of a concert hall. This ambient sound is usually left out of the straightforward stereo recordings.

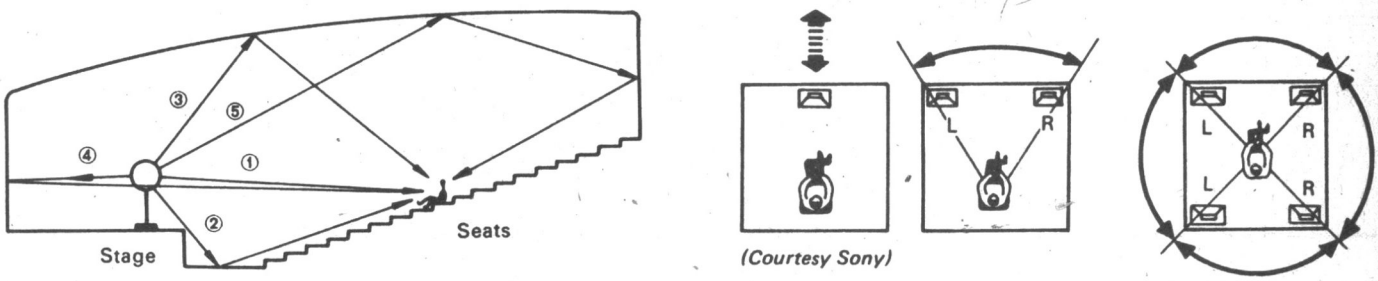
This system is best exemplified by the Dynaquad circuit developed by David Hafler, founder of the American kit firm, Dynaco. Some manufacturers call this synthesized or simulated four channel sound. If not included in the output circuitry (Dynaco and Sherwood are a couple of manufacturers who do build the circuitry into some of their models), such units can be purchased in kit (or even finished) form for under $30. This circuitry, plus two additional speakers, can provide acceptable sound from four channel recordings of the matrixed systems described below as well as many (though not all) stereo recordings.

Second, there are the matrixed systems. The best known matrix system is the SQ system developed by CBS and Sony. SQ, in turn, is similar in theory and results to the SQ system (developed by Sansui and called RM – regular matrix – in Japan) and the Electro-Voice system. Matrixed discs can be played back on regular stereo equipment (and broadcast on FM channels). For four channel reproduction, however, they must be used with a special decoder and, of course, two additional power amplifiers and speakers.

Third, we have a discrete *(separate* channels, an important distinction from matrix, as we'll discuss a bit later) disc system, developed by Japanese Victor (JVC) and backed, not surprisingly, by RCA (the parent company) and a few other disc manufacturers. CD-4 requires a demodulator and two extra power amplifiers and speakers. But it also needs a special CD-4 phonograph pickup with special stylus. Low capacitance cables between the phonograph and the demodulator are usually necessary, too.

Fourth, there is tape. (Remember tape?) It was on tape that we first heard four channel sound about six years ago in the U.S. of the four ways to get four channel sound, tape is the best. It is also the most expensive.

Why Four Channels?



(Courtesy Sony)

A listener in a concert hall hears sounds from all directions. Mono cannot reproduce. Stereo approximates while four channel sound is close to concert hall sound.

If you've been keeping up with the latest trends in audio equipment for home listening, you know that annual improvements in components for stereo reproduction have generally been minimal. Most of the changes have simply involved lower prices for better sound. Receivers, pickups, and loudspeakers in the same price range tend to sound more and more indistinguishable from each other. In other words, the science of recording stereo and playing it back at home has come to the point of seriously diminishing returns.

Despite having come very close to perfection, very few people would argue that stereo sound is nearly as realistic as live music itself. This lack of reality occurs because we hear many sounds in concert halls and other live presentations which are missing from even the best stereo recordings.

Our diagram of the sound paths in a typical concert hall give an idea of why stereo can't imitate real life. (This diagram is a highly simplified picture, yet it does illustrate the complexity of the process.) We have shown five major sound paths (in only one plane), which are just a few of the infinite number of paths of the sounds which reach a concert-goer's ears. Most of these are indirect paths – we call them "reflections" – from the ceiling and walls of the concert hall. And it is these reflections that make up the ambience.

Ambient sound reaches the listener's ears a few milliseconds after the direct sounds have been heard. The ambient sounds are diffused by deflections from the innumerable angled surfaces. And they're heard for only brief moments, decaying (growing weaker) rapidly. The three characteristics of ambient sound – innumerable reflections, delay after direct sound, and decay of these sounds – taken together provide the good (or bad) acoustics of a concert hall. They give heightened realism.

Ambiophony (Stereo Ambience)

The simplest way to recapture ambience of a recording scene is to include echo effects. Early attempts to make a recording seem "live" therefore included echo. Whether the recording had been made in a large hall or not was of little importance after engineers discovered that listeners *liked* the echo (reverberation) effect.

Echo became very important in recording long before stereo. In fact, for many years before stereo, manufacturers marketed "reverb" units very successfully. Best known of the home units was the Fisher "Spacexpander", a simplified version of the elaborate reverberation chambers used in professional recording studios. If a large recording hall was unavailable, the engineer simply plugged in his electronic reverberation and – presto! hall ambience.

Stereo recordings of recent years have, in fact, included a goodly amount of ambient sound information and they frequently give us sound which suggests the size (huge, simply large, or small) and kind of recording arena in which the performer is likely to be heard live, unless the recording has been made in a purposely dead studio which provides few, if any, reflections.

Still, two speakers cannot beam those ambient sounds at us nearly as realistically as can additional speakers. To recreate the ambience of the original recording, additional loudspeakers must be added behind the listener to carry the ambient sound. In addition to the added loudspeakers, we must provide some way of electronically separating the ambient (direct) sounds from the main (direct) sound of the front speakers.

The circuit Dynaco developed several years ago (and called Dynaquad) is nothing more than an electrically simple resistive network. This, and variations on the theme, aim at extracting whatever ambient sounds may be hidden in the stereo recording due to accident (or otherwise) of the phase relationships of the recording microphones. Thus some stereo recordings provide excellent ambient sound when processed through a Dynaquad or similar matrixing network to two additional rear or side speakers. Other stereo recordings will yield little or no ambient sound. It's a matter of experimentation and chance.

One interesting use of these speaker matrixing circuits (also described, perhaps more appropriately, by some firms as "synthesized" or "simulated" quad) is that true matrixed recordings (SQ, QS, et al.) provide realistic, though usually inaccurately positioned, four channel sound when played through these speaker circuits.

Strict use of the word "matrix" might confine it to SQ- and QS-type systems, which require electronic decoders, and two additional amplifiers rather than the simple resistive network (with no extra amplifiers).

The simpler scheme is being employed increasingly in packaged stereo and console sets, allowing their advertising to say "This set will play four channel sound." It's not a lie, but neither is it full four channel of the type described hereafter.

Matrix Four Channel: SQ and QS

QS stands for Quadraphonic Stereo and SQ for Stereo Quadraphonic. SQ, a trademark of CBS Inc., and QS, from Sansui, are both compatible with regular stereo equipment. That is, they can be played on standard stereo phonographs, through two speakers, and we'll get proper stereo sound from them. But add an SQ (or QS) decoder (plus the requisite extra amplifiers and speakers) and you get true four channel sound, not just some ambience. But these systems provide less separation between Front and Rear speakers than is possible with CD-4 (discrete) records.

The last disc system is the one which, in our opinion, provides the best sound today and the most promise for excellent four channel disc sounds in the future. It's the CD-4 discrete disc system (CD stands for Compatible Discrete) which JVC and RCA support. Other, non-RCA controlled, companies such as Atlantic, Nonesuch, Elektra, and other disc firms also support the CD-4 system.

Capable of providing sound with better separation between the four channels, this system also requires the most elaborate circuitry and equipment. Included in this equipment is special stylus and pickup, special cables, and even more attention to clean discs and carefully adjusted electronics. The electronics for CD-4 is called a demodulator, to differentiate it from the decoder(s) used by the matrixed systems.

Although the CD-4 system *can* provide better 4-c from discs than SQ or QS, the only really discrete sound (total separation) available as this is being written still is on tape.

A majority of all four channel receivers now being produced have the capability of playing SQ records (and SQ broadcasts, which we'll talk about later). SQ-encoded discs require an SQ decoder to unscramble the SQ matrixed signals engraved into the two walls of the SQ disc record. Since there are many more SQ records available in North America (at least at the present time) than CD-4 (or, for that matter, QS) discs, let's examine the way SQ works. (QS circuitry is similar to SQ; only the details of matters like phase angle and so on are changed.)

In SQ recordings, each wall of the disc carries a composite of the four signals which will be played back. They mix these in various mathematical (phasor) proportions. For the mathematically inclined, the following in an explanation of SQ derived from a CBS Laboratories' discussion of SQ logic. Those not mathematically inclined may skip these paragraphs.

THE MATHEMATICS

Let L_f represent the Left Front channel. R_f represents the Right Front. L_b and R_b, of course, stand for the Left Rear (back) and Right Rear respectively. R_t means Right Total (Right Front *and* Back) and L_t stands for the Left Total (Left Front *and* Back).

Phase angles of each signal (anything between −180 and +180 degrees) are represented by the letters m and n and by four coefficients A,B,C, and D. Their values range between Zero and One, depending on the results desired by the de-

signers (CBS Labs in this case). So R_t is equal to $AR_f+BL_f+CR_b/m + DL_b/n$. That is, the Right Total signal includes the four signals designated, with phase angles and coefficients as indicated. The Left channel Total signal may be mathematically represented by a similar means.

CBS Labs chose coefficients for SQ of A = 1, B = Zero, C = −0.7, and D = 0.7. m and n are set equal to phase angles of 90° and 0°. Substituting these angles and coefficients into the terms for R_t and L_t, and SQ disc (played in stereo only) is seen to present the total Left signal in the Left Front channel and the total Right signal in the Right Front channel. All four signals originally recorded will be heard.

A Verbal Explanation

In four channel listening, the SQ matrix decoder shifts the two Total signals, recombining them through phase shift networks to produce the four original signals. At least, the decoder *approximately* reproduces the four original signals. The Front channels will still present the total Left and Right signals, just as in stereo, but the Rear channels will also be reproduced. That is, there is considerable cross-talk between the Left Front and Left Rear (and between the Right Front and Right Rear) channels. Fortunately, however, there is full (about 20 dB) separation between the two Front channels and between the two Rear channels.

Scanning this statement, then, it might appear that the four channel effect of SQ is severely limited by the cross-talk. However, careful recording methods, combined with the phase shifts introduced, produce good *audible* four channel effect with most recordings. Some recordings do have a certain vagueness of placement of channels sounds. The most noticeable is usually when a front-centred soloist is recorded. Such solo voice or instrument should naturally appear equally only in the Front speakers; however, it also appears equally (down only 3 dB) in the Rear speakers. This tends to make the soloist sound as though he's everywhere at once (or, as some critics might say, sound as if he's *nowhere* at once).

CBS Labs has worked out ways of improving the apparent separation of the four signals with advanced "logic" circuits, of which there are two general kinds, both more advanced than the basic SQ decoder. One is more advanced (and expensive) than the other.

The least advanced of these two circuits is the "Front-to-back" logic decoder. Many firms refer to this as a "Logic" circuit or "SQ Logic". The better decoders are called "Full Logic", "Wave-Matching Logic", or "Phase Logic" decoders.

When a soloist is present in only one (or perhaps two) channels, the Full Logic system provides sound that is just about as good as discrete quad (either CD-4 discs or quad tapes). But, when there are two or more soloists going at once (often in different channels), the results are less pleasing and, sometimes, downright odd sounding. The reason is that the logic dictates changes in the amount of gain (amplification) for the various channels, according to the loudest signal present in any channel at any moment. The logic can perform its function pretty well when there is clearly one voice (soloist) in one (or perhaps two) channels. But if two (or more) loud voices are recorded, the logic tries to shift the gain between various channels rapidly, often to the detriment of one soloist or the other, with misleading sonic results. And no logic system can produce improvement in the cross-talk characteristics when there are solo voices going in all four channels at the same time.

The three levels of SQ decoders also include the simplest, described in the literature and on the Front Panel of receivers as "SQ" or, sometimes, as the "SQ Decode". These relatively simple decoders add perhaps $50 to the cost of the set and are rarely available as separate add-on units. The most expensive decoders — Gain Riding or Full Logic — have the most complicated (sometimes strangely unusual) names. They may add more than $100 to the cost of a receiver and can cost more than $200 in separate box form. The middle grade of decoder (Front-to-Back Logic) for SQ may add as much as $100 to the price of a receiver. So the manufacturer's choice of circuitry is definitely determined by the economics of the situation.

Some Aural Obervations

Listening to a great many SQ-encoded discs with the various kinds of SQ decoders reveals the following:

(1) Basic SQ, using the simplest kind of decoder, yields considerable four channel effect, much more interesting than the same recording played in stereo. But it cannot supply nearly as good four channel effect as the other, more expensive and sophisticated, decoders.

(2) The Front-to-Back Logic decoders may sound nearly as good as the most expensive ones, with most symphonic recordings, as other material recorded from a typical listener's position. Such records, with the medium-priced decoders, can sound about as good as the same material played through the most complex decoder.

(3) But many of the four channel recordings being made today, particularly those with the listener surrounded by the artists and with solo voices coming variously from each of the four channels, cannot be handled with full justice by any but the most expensive, Full Logic, decoders. Under the *best conditions,* such records can sound about as good as *properly reproduced* discrete sound.

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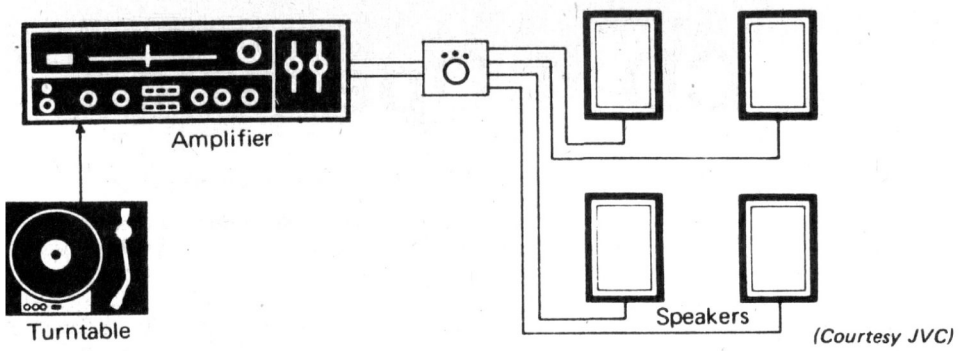
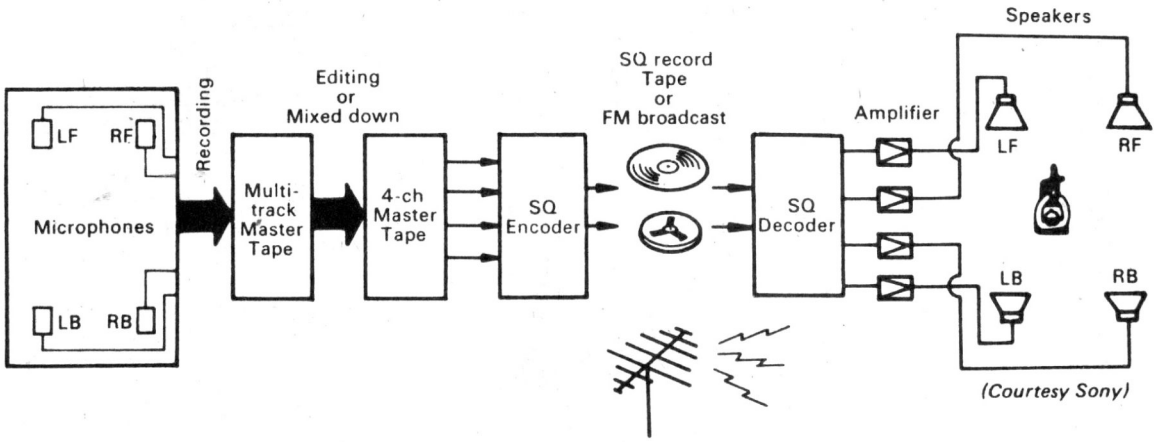
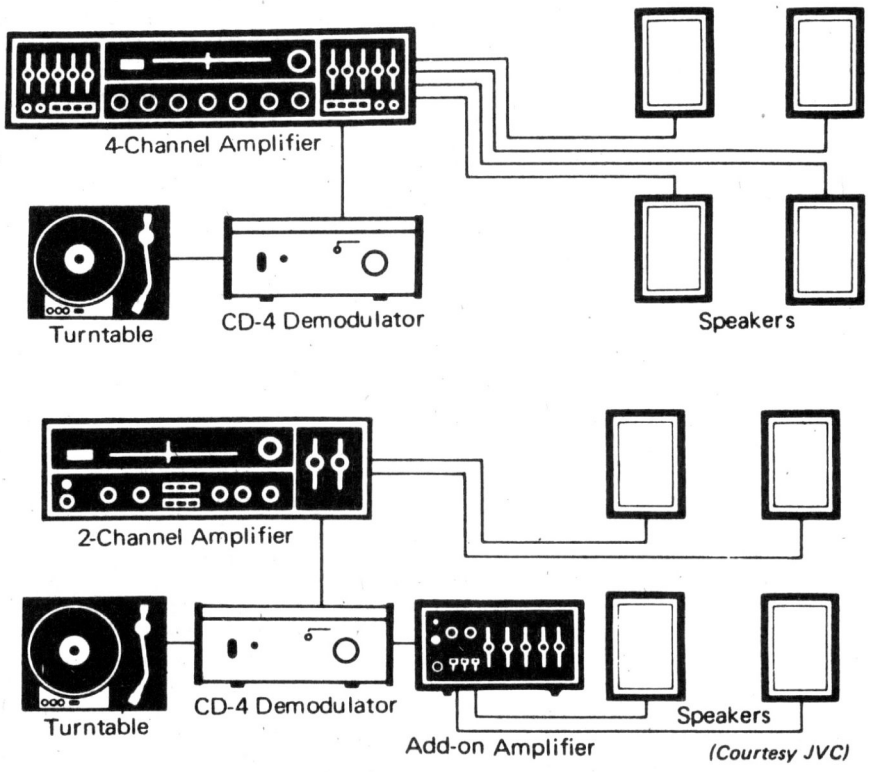


Synthesized four channel sound (sometimes called "simulated") can somewhat recover concert hall ambience from stereo signals by using only a simple adaptor between stereo amplifier and four speakers.



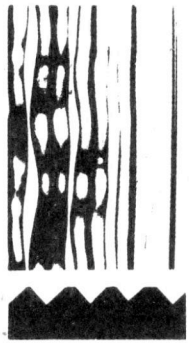
Typical quadriphonic matrix system such as SQ is shown from recording (or broadcast) through matrix encoding, to decoding in listening room.



Two ways of adding CD-4 disc capability to existing system. CD-4 pickup is used, and special low capacity cables go from turntable to the CD-4 demodulator.

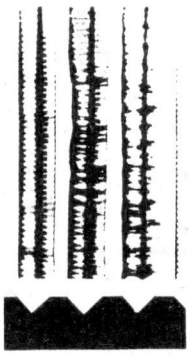
CD-4 Operation

The CD-4 system for disc records requires that the grooves carry four separate signals in the two grooves. In addition to the two regular (stereo) signals for the front speakers — one recorded on each groove wall — the information for the rear channels is carried in the form of 30 KHz waves (± 15 KHz) according to the audio information required for those channels. This means that the pickup and stylus must be able to respond not just to the 30 — 15,000 Hz for normal stereo but all the way up to 45 KHz (30 + 15 KHz)! For a stylus to pick up such frequencies, it must have greater compliance than a plain stereo pickup and it must be pressed into the groove with greater VTF (vertical tracking force).



GROOVES AND CROSS SECTIONS OF CONVENTIONAL STEREO RECORD

To keep the increased VTF from damaging the grooves, some new stylus shapes have been engineered. The first came from the JVC firm and is known as the Shibata stylus after Norio Shibata, the designing engineer. Similar shapes have been brought out by Stanton-Pickering (called the Quadrahedral stylus), B&O (Pramanik), and Empire, among others. All the designs are fairly closely related and the Shibata stylus shown here closely resembles the shape of the others.



GROOVES AND CROSS SECTIONS OF CD-4 SYSTEM RECORD

All these stylii involve reduction of the stylus area from front to back (as the groove goes past the needle tip) and increasing the amount of vertical contact between the stylus tip and the groove. This provides the additional surface-bearing area required to support the extra VTF without hampering the ability of the tip to follow the even-wilder groove wiggles which CD-4 provides.

One happy by-product of CD-4 seems to be that these four channel pickups play stereo discs even better than most previous stereo pickups.

CD-4 enjoys significantly less leakage between channels than is the case with SQ and QS sound. That accounts for the identification of CD-4 as *discrete* sound. Actually, separation is perhaps only 20 dB or slightly better between *all* channels, but this is more than adequate to make them sound entirely separate. (Remember that, although the matrix systems may have 20 dB or better separation between Left and Right channels, they normally have no more than 3 dB between Front and Rear.)

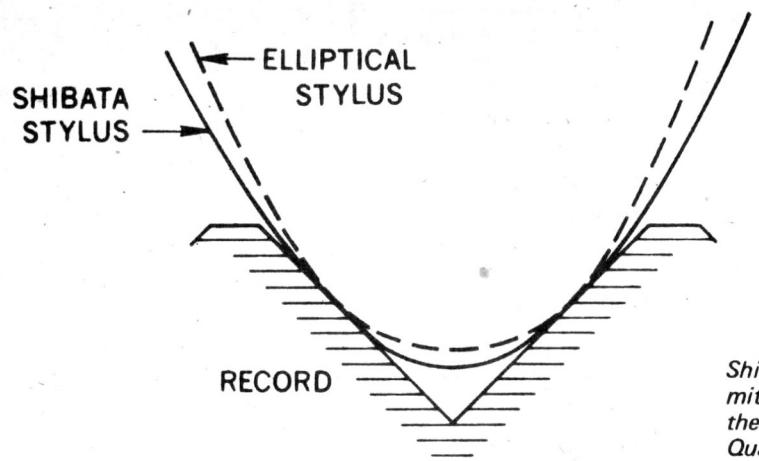
The 30 KHz carrier signals are demodulated by the electronics (called, appropriately enough, the "demodulator"), which removes the desired signal from the high frequency carriers and feeds it to the extra power amplifiers that service the Rear channels. Because the pickup has to feed the modulated carrier signals to the demodulator, the cables between the pickup and the demodulator must be low-loss cables. At least, this condition must hold if the pickup, as are most, is of the magnetic type. It is possible to replace these cables — in most turntables — fairly readily and this is a fairly accepted practice now when a stereo pickup is turned in for a quadriphonic unit.

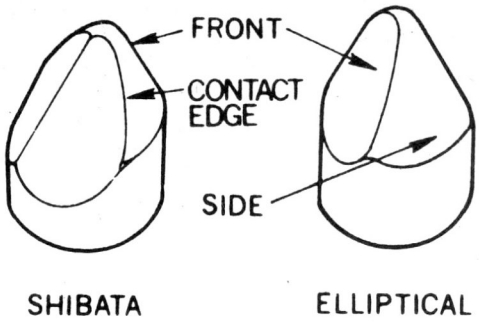
Pickups For CD-4 Records

There are now a number of phonograph pickup cartridges available to play CD-4 recordings. At last count, there were 10 models with more coming along every month or two. These range in price from around $150 down to below $20, with the most expensive ones doing a very creditable job so far as frequency response and separation are concerned.

All of these cartridges, as we've noted above, require low capacitance cables between the turntable arm and the demodulator. The exception is the Grado model FTR+1. This unusual pickup is equipped with a *spherical* tip (like the original stereo tip) rather than the Shibata-like shape that has become virtually standard. In fact, it is even different from the elliptical shape that has become just about standard for stereo in recent years. Yet the Grado appears to perform very well, even if it doesn't conform to the standard design.

In a recent test, I observed that the frequency response of all nine of the pickups tested was flat within the audio range but that most of them varied widely in the supersonic region above 20 KHz. Most of the pickups had a resonance (hump) near 30 KHz. Separation was 20 dB or better for all the pickups, with the Grado and the Pickering UV-15/2400Q producing 25 dB separation over most of the audible range.





Shibata stylus shape fits groove walls over longer arc, permitting narrower stylus radius, which is needed to follow the groove wiggles of CD-4 disc recordings. Pickering's Quadrahedral stylus accomplishes a similar result.

Four Channel Tape

Although the first four track recordings were made on open reel tape recorders and played back in demonstrations by Acoustic Research and Vanguard on similar tape machines, commercially released four channel tapes have not proliferated like the quadriphonic discs. That situation, however, is beginning to change.

The simplest transition from stereo to four track recordings was on open reel tape machines because the technology was already there. All that was required was rearrangement of the playback heads and addition of two more amplifiers. The standard stereo tape track arrangement is shown in Figure 1 in which two tracks (the Right and Left channels) are played in one direction and, when the tape is reversed, the other two tracks are played. In each case, the same two gaps of the tape playback head play the Left and Right tracks, with the tracks falling into correct position when the tape reels are reversed.

The four channel playback uses exactly the same tape but the head now has four instead of only two gaps. Consequently the only changes in switching from stereo to quad on tape are (a) the addition of the two gaps, (b) the addition of two tape head preamplifiers, and (c) reduction of the length of playing time by one-half. The separation between tracks is nearly perfect (45 to 50 dB is typical) so this method offers virtually total discrete quadriphonic sound. The best that discs can do (with the CD-4 system) is about 20 to 25 dB separation between channels.

Of course, four channel open reel tape recorders cost much more than their counterparts in a four channel disc system. From $600 up is the standard price range for a four channel open reel tape deck whereas an existing turntable can be modified for only $150 for a CD-4 disc demodulator and $100 or up for a new CD-4 pickup.

Cartridge Quad

Although there are still thousands of automobiles equipped with the four track (two in each direction) stereo CARtridges that were first on the market, the dominant cartridge is the more recently arrived eight track promoted by RCA and other firms. These stereo 8-track *endless loop* cartridges were first sold for automobile use (which is why we refer to them regularly as CARtridges) and, although their use in home systems is becoming increasingly common, they remain primarily a car-oriented medium.

The arrangement of eight tracks on quarter-inch tape is shown in Figure 2. In standard stereo playback, the tracks marked 1 and 2 would be played first. When the loop has made a full pass, a metal foil strip bonded to the tape activates a switch and solenoid. The switching action moves the tape playback head downward an appropriate distance so that the next two stereo tracks, 2 and 6, can be played. And, when these tracks have been played, the metal foil again activates the switch and the solenoid moves the playback head down enough to play the next set (3 and 7) of stereo tracks. And so on. After tracks 4 and 8 have been played, the switching action moves the tape head to its initial position to play tracks 1 and 5 again.

Most CARtridge machines will continue playing this sequence of four stereo groupings indefinitely, stopping only when the cartridge is removed from the player.

In adapting this cartridge to the four channel format, only two program loops are available instead of four, since each pass of the tape uses up four tracks. The playback head has four gaps, as shown in Figure 2, and, when the head moves at the end of one program loop, it shifts from the top half of the tape (tracks 1 through 4) to the bottom half of the tape (tracks 5 through 8). This is known as Q-8.

The newer cartridge machines designed for Q-8 play have some limited compatibility with the earlier cartridges. If a stereo cartridge is placed into the quadriphonic player, it will play — nor-