Anatomy of a Stereo Phono Cartridge

BY JULIAN HIRSCH
Hirsch-Houck Labs

ALMOST every stereo system today has a turntable that is equipped with a stereo cartridge for playing disc recordings. The stereo phono cartridge itself is a miniaturized pair of electric generators that are coupled to a single-jewel stylus. The stylus follows the undulations of the V-shaped record groove. Each of the groove walls, containing one of the two stereo program channels, moves the stylus independently to produce an electrical voltage at the appropriate output of the phono cartridge.

The two basic types of modern phono cartridges are amplitude-responding and the velocity-responding. The amplitude-responding variety's output voltage is proportional to the magnitude of the stylus motion, while the velocity-responding cartridge generates a voltage that is proportional to its velocity, which is the product of amplitude and frequency. Examples of amplitude-responding cartridges include piezoelectric (crystal and ceramic), strain-gauge, and photoelectric designs. Magnetic cartridges, used almost exclusively in modern high-fidelity sound systems, are velocity-responding types.

The magnetic cartridge operates by varying the strength of a magnetic field surrounding a coil of wire or by varying the position of a small wire coil in a fixed magnetic field. Both designs are capable of generating a voltage in a coil. Magnetic cartridges are known by various names, including moving-iron, moving-magnet, induced-magnet, variable-reluctance, and moving-coil, depending on the specific design employed in their manufacture. No matter what the name, each cartridge type offers certain advantages and disadvantages, and all are capable of equivalent performance.

The output of a magnetic cartridge, being proportional to frequency, requires equalization to produce a flat frequency response. The output of the cartridge is very low, generally only a few millivolts. Hence, the required amplification and equalization to produce a usable signal for the sound system must be supplied by the phono-preamplifier section of the system's amplifier or receiver.

The mechanical design of the moving elements in the phono cartridge is usually more important than the method of transduction—a demand not always appreciated by the user. The stylus must be able to reverse its direction thousands of times each second in exactly tracking the complex modulation on the groove walls; yet, it must not damage or permanently alter the shape of the groove modulation pattern.

Diamond, which can be shaped and polished with great accuracy, is universally used for high-quality playback styli. The tiny jewel (which may be difficult to see with the naked eye) is mounted with a precise orientation at one end of a light, hollow metal tube that is pivoted near the other end. The deflection of the tube by the motion of the stylus moves a portion of the magnetic circuit to generate the output voltage.

The dynamic contact force between the stylus and the groove, which determines the amount of tracking force needed, depends on several factors. Among these are the mass of the moving elements that must be accelerated during the rapid direction changes and the compliance (the inverse of stiffness) of the stylus cantilever system. Designed to track at forces as low as 1 gram, the best modern phono cartridges often have an effective stylus mass of less than 1 milligram and a compliance of 35×10^{-6} centimeters/dyne or more. Such cartridges are relatively delicate and should be used only in properly designed tonearms. Cartridges designed for low- and medium-priced record players have sturdier and less compliant stylus assembly systems that are meant to operate at forces of 2 to 3 grams. Although there is sometimes surprisingly little difference in sound quality between a 3-gram cartridge and one rated for 1-gram operation, the latter can be expected to produce somewhat less record wear over a long period of time. Cartridges requiring a force of 4 grams or more should not be used for serious high-fidelity listening applications.

Although stylus mass and compliance ratings of cartridges are sometimes published, they are of limited usefulness in judging cartridge quality since many other unspecified factors are involved. In the absence of other information, the manufacturer's rated range of tracking forces is a good indication of overall cartridge performance (a lower force implying a generally superior product), although not necessarily of its listening quality compared to other cartridges.

The tracking ability of a cartridge refers to its ability to faithfully reproduce high recorded velocities (levels) over a wide frequency range at a given tracking force. Exceeding the tracking ability of a cartridge causes an unmistakable harsh, shattering sound. Sometimes, but not always, increasing tracking force will help. Almost all cartridges operate best when used near the high end of the recommended tracking force range. Few manufacturers provide specific information on tracking ability, but test reports such as those in this magazine serve as a useful guide.

The shape of the tip of the stylus jewel, which is the only part of the cartridge to actually contact the record, is an important factor in performance. The standard stylus has a spherical tip with a radius of 0.0007 in. (0.7 mil). More accurate tracking of very short recorded wavelengths (the higher frequencies, especially near the center of the record) is possible with a small tip radius, such as 0.5 mil. However, this causes a higher pressure per unit of area on the vinyl record, which can increase record wear unless a very low tracking force is used. A 0.5-mil stylus is not well suited to playing monophonic LP records.

An excellent compromise in stylus design, now widely used, is the elliptical stylus. Across the record groove, it has a radius of 0.7 to 0.9 mil, but along the length of the groove the radius is only 0.2 to 0.4 mil. The elliptical design yields superior high-frequency performance without excessive record wear as well as improved quality on mono discs. However, the most common elliptical size of 0.2×0.7 mil should not be used at forces exceeding 2 grams, which limits its use to the higher-priced phono cartridges. ◈