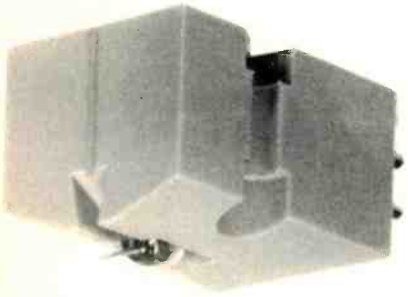
Denon DL-103D Phono Cartridge, DA-307 Tonearm, and AU-320 Transformer

Manufacturer's Specifications

DL-103D Phono Cartridge

Generating System: Moving coil.
Output Voltage: 0.25 mV (1 kHz, 50 mm/S, horizontal).
Channel Sensitivity Difference: 1 dB or less at 1 kHz.
Channel Separation: Over 28 dB at 1 kHz.
Electrical Impedance: 33 ohms, ±20 percent at 1 kHz.
Compliance: 12 x 10^{-6} cm/dyne (on disc).
Recommended Tracking Force: 1.5 grams, ±0.2 grams.
Playback Frequency Response: 20 to 65,000 Hz.
Weight: 7.5 grams.
Recommended Load Resistance: 100 ohms or more, except when transformer is used.
Price: $267.00.



DA-307 Tonearm

Type: Static balance, dynamic damping.
Overall Length: 332 mm (13.071 in.).
Effective Length: 244 mm (9.61 in.).
Overhang: 14 mm (0.55 in.).
Height Adjustment Range: 42 to 70 mm (1.65 to 2.76 in.).
Acceptable Weight of Cartridge: 5 to 10 grams.
Price: $275.00.

AU-320 Transformer

Step-Up Ratio: 1:10 at 40 ohms: 4 kilohms.
Primary Impedance: 3 ohms, 40 ohms.
Secondary Impedance: 4 kilohms.
Frequency Response: 10 Hz to 100 kHz, ±1 dB.
Crosstalk: 60 dB or less, 20 Hz to 50 kHz.
Overall Dimensions: 97 mm (3.82 in.) W x 65 mm (2.56 in.) H x 160 mm (6.3 in.) D.
Weight: Approx. 800 grams (28.57 oz.).
Price: $160.00.

In previous tonearm reports, we have evaluated low-mass types. For this report, we had a chance to check out the Denon DA-307 tonearm which is a medium- to high-mass device. It is designed for use with relatively low-compliance cartridges, such as the Denon moving-coil DL-103D, also reviewed here. Moving-coil cartridges are designed to be extremely lightweight reciprocals of moving-coil disc cutterheads used to make original disc masters. While this reciprocity of design does not guarantee exceptional performance, in the past few years they have gained a reputation for excellence and a large following in the audiophile market. There are always trade-offs, of course, and to use such a cartridge, the audiophile must contend with such things as low output voltage and non-user-replaceable stylus. (There are some moving-coil designs, notably from Audio-Technica, Osawa and Satin, which do have a user-replaceable stylus).

The compliance of the Denon DL-103D cartridge is about 12x10^{-6} cm/dyne, and it matches well the effective mass of the DA-307 tonearm, which is about 20 grams with the DL-103D installed. The inductance of the coils proved too low to measure, and the 32.9-ohm resistance of the coils provides the major part of the internal impedance.

Since the low output voltage of the DL-103D cartridge requires a step-up device, such as a pre-preamplifier or transformer, we used the Denon AU-320 transformer which provides a nominal 40-ohm input. This input is designed to match the nominal 33-ohm internal impedance of the DL-103D. When a pre-preamplifier is used, Denon recommends that its input impedance be greater than 100 ohms. The Denon AU-320 transformer also provides a 3-ohm input which may be switch selected.

The Denon DA-307 tonearm was mounted on a Denon DP-6000 turntable. This combination is also available preassembled, as the Model DP-6700, which was used for this report. This is certainly an impressive combination, and it is easy to see why Denon, known in Japan as Nippon Columbia, has been a major supplier to NHK, the Japanese broadcasting corporation. For the past few years, they were represented in the U.S.A. by American Audioport. Denon has more recently set up a division in New Jersey, and it is headed up by Eric Fossum who was previously in charge of Denon products for American Audioport. Readily available product support, especially for imports, can be a major consideration to prospective purchasers; since the DL-103D must be returned for stylus replacement, it is especially true in this case.

Because previous reports on tonearms have been made us-

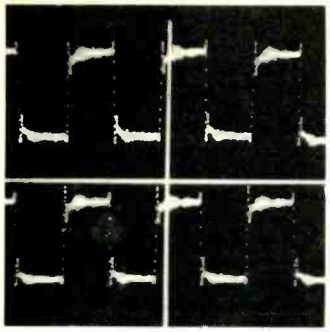


Fig. 1 — Response of Denon DL-103D cartridge in DA-307 arm to 1-kHz square wave of CBS STR-112 band 1, left channel. Top trace is without AU-320 transformer, bottom is with transformer at 40-ohm setting.

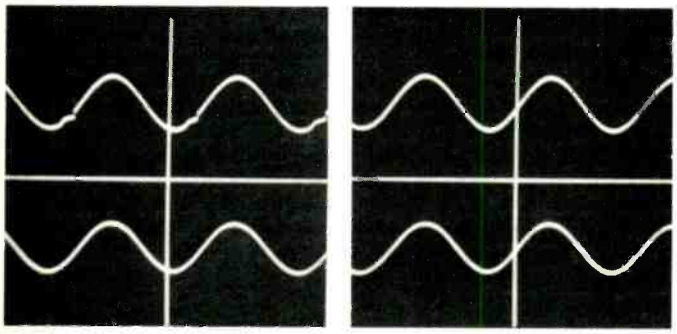


Fig. 2 — Response of Denon DL-103, DA-307, and AU-320 to 300-Hz signal in band 9 of CBS STR-112, +18 dB re: 11.2 μM. Fig. 2A, left, is with 1.7 g tracking force and 2.5 g sidethrust correction. Fig. 2B, right, is with 1.8 g tracking force and 2.8 g sidethrust correction.

ing the Pioneer PLC-590 turntable, we should make some mention of some of the features of the Denon DP-6000 direct-drive turntable. This turntable was supplied with a heavy wooden base and a clear plastic dust cover. The base included four large mounting feet which are a combination of rubber and conical spring. Each of the feet is adjustable so that the turntable may be leveled. The hinges which hold the dust cover to the base are also adjustable so that the cover may be set to stay open at any given angle. This dust cover is also removable, which is handy in case the whole unit were to be mounted in a drawer or cupboard.

The turntable has speeds of 33⅓ and 45 rpm. The 4-lb. turntable platter is driven from an a.c. servo motor which is phase locked to a crystal oscillator. A 9-in. diameter magnetic track is employed underneath the turntable providing for 1000 pulses per rotation. A magnetic recording head reads these pulses, and suitable circuitry is employed resulting in a pulse-width-modulation signal which is fed through an appropriate amplifier to the a.c. servo motor. The turntable speed can be locked to the crystal control oscillator or adjusted by means of a variable knob to ±6 percent of the selected speed. During turn-on or between speed changes, a special speed-up signal or d.c. braking signal is fed to the motor. The d.c. braking signal is also available when the unit is turned off, which helps to slow down the turntable rotation more quickly than otherwise would occur. The turntable is fitted with a 1-lb. rubber mat and also comes with a 145-gram weight which fits over the spindle once the record is put in place. The heavy rubber mat and the weight are intended to reduce record vibrations during playing. It was determined through experimentation that the DP-6000 turntable was relatively impervious to both airborne and structural vibrations

Measured Data

Denon DA-307 Tonearm

Pivot-to-Turntable Center Distance: 9.06 in. (230 mm).
Pivot-to-Stylus Distance: 9.5 in. (244 mm).
Pivot-to-Rear of Arm Distance: 3.46 in. (88 mm).
Arm-Rear Clearance from Turntable Center: 12.52 in. (318 mm).
Overall Height Adjustment: 1.11 in. (28 mm).
Maximum Tracking Force Adjustment: 10 g.
Tracking Force Calibration: 2.5 g per 360 degree revolution of counterweight in 0.1-g steps.
Tracking Force Accuracy: Marked vs. measured, 0.5/0.5; 0.7/0.7; 1.0/0.9; 1.2/1.1; 1.5/1.4; 1.7/1.6; 2.0/1.8, and 2.5/2.3.
Cartridge Weight Range: 5 to 10 g.
Counterweight: Integral.
Counterweight Mounting: Slip fit into arm tube.
Sidethrust Correction: Variable magnetic; uniformity varies with disc radius, see test.
Pivot Damping: None.
Headshell Offset: 24 degrees.
Lifting Device: Oil-damped lever.
Fingerlift: Integral with headshell.
Headshell Weight: 6.0 g.
Mounting Screws Weight: 0.4 g.
Overhang Adjustment: Slots in head shell.
Bearing Alignment: Excellent in both planes.
Bear Friction: Too low to measure.
Bearing Types: Vertical, two needle point; horizontal, ball and race.
Lead Torque: Too low to measure.
Dynamic Mass: See text.
Lead Capacity: Total, 53 pF; arm leads, 6 pF; external leads, 47 pF.
Lead Resistance: Total, 1.05 ohms; arm leads, 0.05 ohms; external leads, 1.0 ohm.
Lead Length: 47 in. (185 mm).
Structural Resonance Minor resonance at 90 Hz.
Base Mounting: Locknut on 0.75-in. dia. threaded metal tube with 1.875-in. dia. flange.
General Comments: Arm lift and arm height independently adjustable for different turntable applications. Forward part of arm is isolated from pivots via rubber.

Denon DL-103D Phono Cartridge

Serial No. 5130	Left	Right
Inductance, mH	See text	
Resistance, ohms	32.9	32.9
Output, mV/cm/S at 45° (B&K 2009, band 3)	0.27	0.27
Dynamic Tracking Force, grams required to track B&K 2010 (Gms x 980 = dynes)		
Band 3, 0 dB (= 7.07 cm/S at 45°)	0.7	0.7
Band 4, +2 dB	0.8	0.8
Band 5, +4 dB	1.0	1.0
Band 6, +6 dB	1.8	1.8
Band 7, +8 dB	2.0†	2.0†

†Visual distortion on scope trace.

Tracking Force vs. Radius, grams
(HFS-75, 300 Hz, +15 dB re 1.12×10^{-3} cm)
Outer grooves, 1.1 grams
Middle grooves, 1.1 grams
Inner grooves, 1.2 grams

Cartridge Mass: 7.9 grams.
Microphone: Excellent.
Hum Rejection: Good.
High-Frequency Resonance: 66.7 kHz.
Rise Time: 9.0 μS, see text.
Low-Frequency Resonance: 8 Hz.
Low-Frequency Resonance Q: 6.0
Recommended Load Resistance: Above 100 ohms, see text.

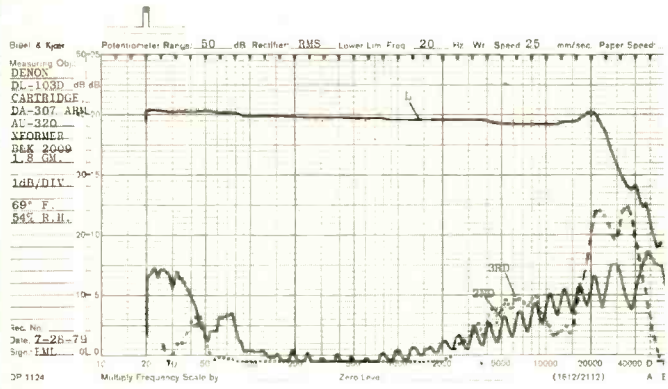


Fig 3 — Second and third harmonic distortion vs. left-channel output. Distortion is very low from 100 Hz to 1 kHz, and the distortion of the test record is included (Distortion components are measured only to 20 kHz).

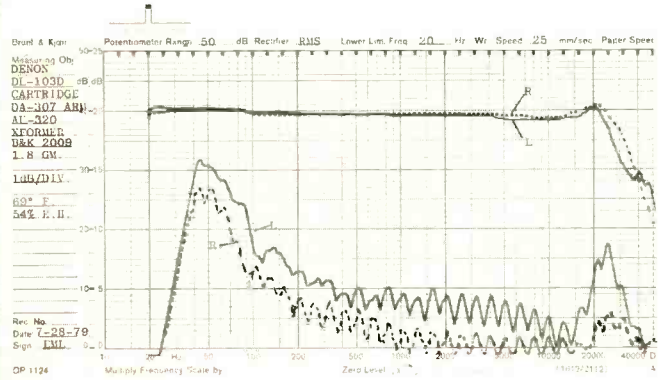


Fig 4 — Interchannel output vs. frequency. Notches in crosstalk are due to filter switching. Crosstalk from right into left is greater than from left into right. No "fingers" are apparent which indicates that no serious resonances are present to color the reproduction. The effect of the rubber arm decoupler can be seen at 90 Hz.

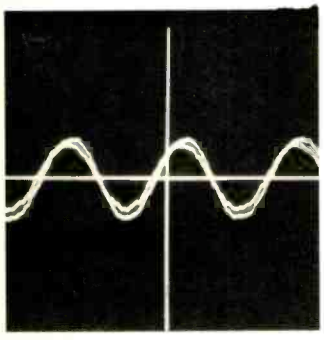


Fig. 5A — Amplitude vs. time on both channels of the B&K 2009 test record, band 3. Sweep is from 20 Hz to 20 kHz, with stop action at 3 kHz.

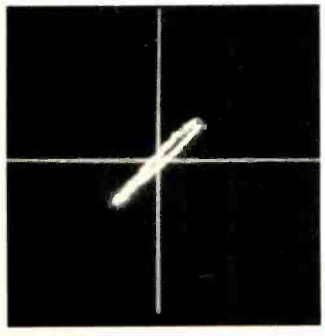


Fig. 5B — X-Y display of the right vs. left channel for the same signal as Fig. 5A. Identical channel output would make a straight 45-degree line.

and therefore did not significantly affect the results of either technical measurements or the listening tests.

The Denon DA-307 tonearm employs an interesting form of dynamic damping which we had not seen previously. In other designs the rear of the arm, which includes the counterweight, is usually decoupled by some means. The usual method is to use rubber between the rear of the arm and the counterweight. The DA-307 has a rubber decoupler on the cartridge side of the tonearm, near the pivots, which decouples the arm tube and cartridge from the main pivots. The cartridge balancing and tracking force adjustment weights on the rear of the arm are divided into two sections, each allowing adjustment of the counterweight. A small knurled wheel at the back of the arm is used to set the initial balance of the arm when the cartridge has been installed. The other adjustment, which adjusts the tracking force, is a rotating ring calibrated in 0.1-gram increments. This ring is calibrated for 2.5 grams for each 360-degree rotation. There are four complete turns, and so the total adjustment range is 10 grams. Denon indicates in their literature that cartridges weighing between 5 to 10 grams may be used with the DA-307 tonearm. The detachable magnesium alloy headshell has an integral finger lift; the DA-307 accepts EIA standard headshells so that other brands of headshells may also be used. An adjustable oil-damped cueing lever is integral with the arm. The bearing friction is claimed to be less than 25 milligrams both vertical and lateral, and this seems reasonable although it was too low to measure accurately. Since the arm was supplied already mounted to the turntable, we did not have a template at hand to check the offset angle of the head. This offset angle is not mentioned in any of the Denon literature but we calculated that the optimum offset angle should be 22.5 degrees. As nearly as we could measure, the offset angle appeared to be 20 degrees. The overhang specified by Denon was 14 millimeters but we calculated that the optimum overhang should be 16.9 millimeters. The slots in the Denon headshell allowed us to adjust the overhang and the offset angle to the optimum values for our tests. The effective mass of the tonearm including headshell (6 grams) and the cartridge (7.9 grams) is about 20 grams.

When first setting up a new tonearm and cartridge combination, one of the tests we usually perform first is to play band 1 of CBS Test Record STR 112, which consists of a 1-kHz square wave. This provides a quick means of adjusting the optimum load resistance and capacity. By alternating between this square-wave test and a swept-tone test from one of the B & K records, it is possible to determine these optimum values. Since the Denon DL-103D cartridge is a very low impedance device, the external load capacity has only a slight effect. We did use this test, however, to determine if there were any major differences between operating the cartridge directly or through the Denon AU-320 step-up transformer. Figure 1 indicates there is very little difference with respect to this square-wave test when using the cartridge directly or through the step-up transformer. The ringing shown in the photographs is at a very high frequency. The major overshoot, on the leading edge, occurs at about 25 kHz, and the ringing, which is relatively damped, occurs at 66.7 kHz. Both of these resonances are well outside the audible band of frequencies. The main reason that they are visible at all is because there is no band-limiting mechanism, either in the cartridge itself or in the input of the measuring amplifier, which would roll off the output at these frequencies. The cartridge is free to show the results of trying to negotiate the severe changes in acceleration required when tracing the square wave on the CBS STR 112 Test Record. Therefore, what appears to be, at first glance, a fault can

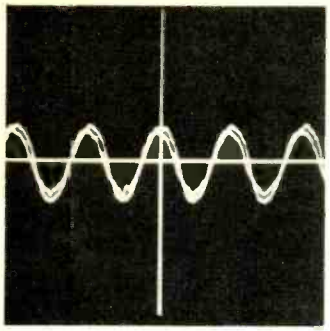


Fig. 6A — Same as Fig. 5A with stop action at 5kHz.

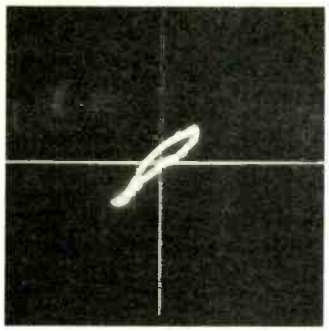


Fig. 6B — Same as Fig. 5B with stop action at 5 kHz.

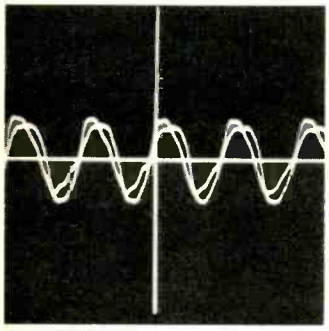


Fig. 7A — Same as Fig. 5A with stop action at 10 kHz.

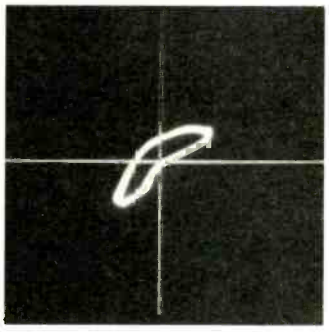


Fig. 7B — Same as Fig. 5B with stop action at 10 kHz.

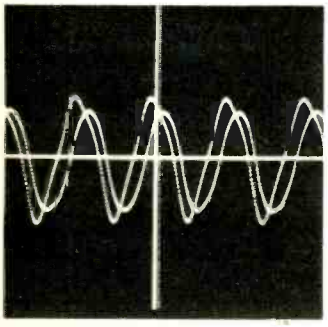


Fig. 8A — Same as Fig. 5A with stop action at 20 kHz.

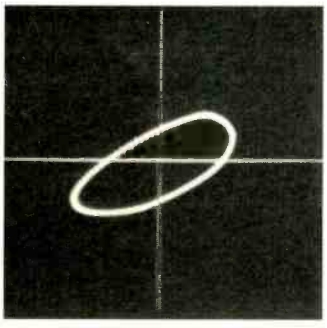


Fig. 8B — Same as Fig. 5B with stop action at 20 kHz.

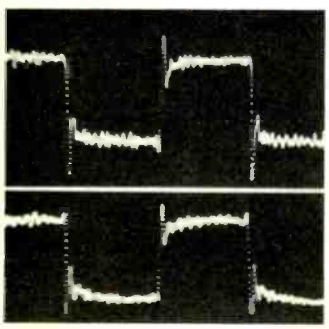
Fig. 9A — Response to 1-kHz square wave from STR-112, 3.54 cm/S. Top trace is left channel.

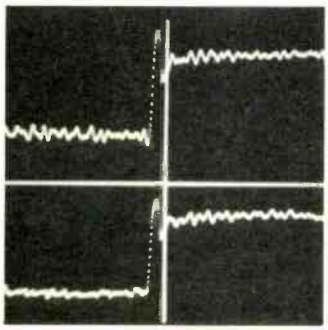
Fig. 9B — Same as Fig. 9A except expanded to show leading edge. Frequency of "ring" at leading edge is 25 kHz; later "ring" is 66.7 kHz.

actually be considered a virtue. It is also, as John Curl has previously pointed out in *Audio*, (Aug., 1979), further proof that extremely high frequencies can be seen at the output of moving-coil cartridges when tracing phonograph records. It is also a further indication that preamp design criteria, which provide high-frequency filtering at, say, 40 kHz, are appropriate. If left unfiltered, such signals can cause distortion in wide-band preamplifiers and power amplifiers. During the listening tests, the listening panel was able to determine that there were subtle changes in the quality of the sound reproduction when such a 40-kHz filter was removed from the signal path. The general listening tests were therefore performed with this 40-kHz filter in the signal path to avoid subtle differences which might occur due to possible amplifier limitation.

Figures 2A and 2B indicate the tracking capabilities of the Denon DL-103D cartridge and DA-307 tonearm combination. Figure 2A shows that the left channel is mistracking on the highest level band. Although the side thrust correction on the DA-307 tonearm is easily adjustable while playing the test record, we were unable to exactly balance the tracking of both channels at the point where the first indication occurred. It should also be noted from the figure that a setting of 2.5 on the sidethrust corrector was needed to accommodate the tracking force at 1.7 grams for optimum results. This sidethrust correcting force is also designed so that it increases toward the center of the disc. Figure 2B is also for the highest level band of the test record STR 112. Raising the tracking force to 1.8 grams and the sidethrust correction to 2.8 allows the Denon combination to track this band. This has to be considered most excellent performance in tracking such a high-level test cut. The listening panel evaluations were conducted using this 1.8-gram tracking force setting. During the listening test no one commented about any sound which could be regarded as being caused by mistracking. During our tests with the British test record HFS-75, we determined that the tracking force required on the inner grooves was slightly higher than that required for middle or outer grooves. It is possible that on some modern digitally-based recordings a tracking force of 2.0 grams might be required but it is recommended that for general use a tracking force of about 1.8 grams be set up.

Figure 3 shows the second and third harmonic components for the left-channel output only. The distortion components from about 100 Hz to 2 kHz are about as low as we have so far measured on any cartridge/tonearm combination. During the listening evaluations, the general consensus was that this combination of cartridge and tonearm provided a very smooth, clean sound, which was neutral almost to the point





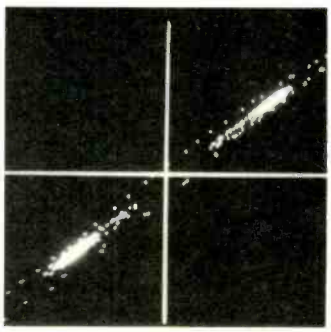


Fig. 9C — Same as Fig. 9A except is a left vs. right presentation. This is an excellent interchannel relationship for a complex signal.

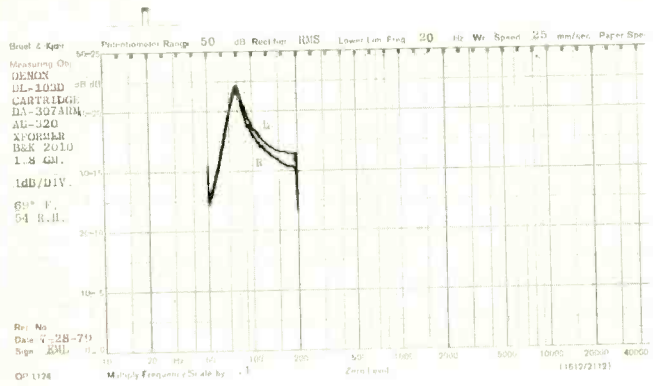


Fig. 10 — Low-frequency resonance due to arm effective mass and cartridge compliance; Q is 6.

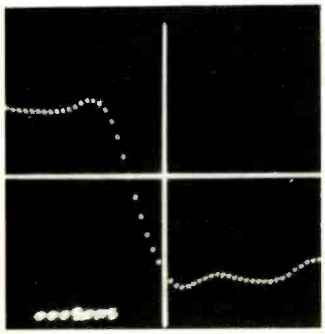


Fig. 11 — Rise time of Denon DL-103D and AU-320 transformer, 9 μS.

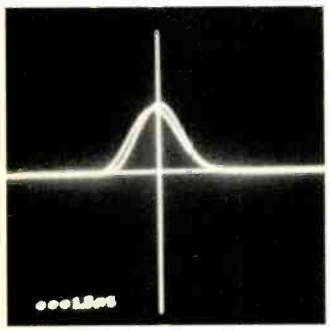


Fig 12 — Response of the AU-320 transformer to 30-kHz cosine pulse shows 1.5- μS delay through the 40-ohm input.

of having no character of its own. The lack of distortion, plus the gentle swayback character of the frequency response curve, may account somewhat for a "reticent" character of the overall sound. The sound of brass, for instance, while having the same general timbre as that of the reference system, appeared to be a little less bright.

Figure 4 shows the frequency response and crosstalk characteristics of the left and right channel. There are no prominent "fingers" sticking up in the crosstalk information, which would indicate resonance problems that could color the sound. While listening to various records which included different instruments and voice, there were no really adverse comments by the listening panel regarding changes in timbre or shifts in spatial positioning for small ensemble or single instruments. Figures 5 through 8 indicate that spatial positioning should be at least reasonable up to 10 kHz. From 10 kHz to 20 kHz there is some shifting in the phase relationship between the two channels. The bending of the ellipse in Fig. 7B also shows, in another form from Fig. 3, the results of nonlinear distortion occurring at 10 kHz. However, none of the listening panel members actually made any comments regarding spatial smearing of instruments such as cymbals which contain energy at these frequencies. It should be pointed out that the multi-microphone recording of drums and cymbals prevalent in modern pop recording could cause some confusion in the sound image.

Figure 9 shows the output for a 1-kHz square-wave signal. Both the left (upper) and right (lower) channels are shown in Fig. 9A; Fig. 9B is an expanded view of Fig. 9A. In Fig. 9B we can see the leading edge overshoot which is caused by some phase shift at 25 kHz. The smaller ripples are at 66.7 kHz and appear to be well damped. Figure 9C shows the relationship between the left and right channels for this 1-kHz square wave, and the pattern in this photo shows that for a complex signal, such as a 1-kHz square wave, the correlation in the time domain is excellent. This indicates that, for complex signals, the spatial perspective and positioning will remain fairly consistent. Comments from the listening panel during the playing of complex music passages by large ensembles indicated that this indeed was true. Figure 10 shows the low-frequency resonance for the combination of the tonearm mass and the cartridge compliance, and this resonance occurs at approximately 8 Hz. The Q of this resonance is 6, quite high by today's standards. This may account for the comments by the listening panel that the lower registers of guitar, piano, and cello seemed to be a little less tight than the reference system. However, extremely low organ pedal and bass drum seemed to be quite good and elicited comments to this effect.

Figure 11 shows that the rise time of the Denon DL-103D cartridge is 9 μS, an extremely fast measurement. This test was performed with the Denon AU-320 step-up transformer in the circuit which makes the results even more amazing.

Figure 12 shows the response of the Denon AU-320 transformer by itself to a 30-kHz cosine pulse. There is a 1.5-μS delay added to the signal when this transformer is used in the 40-ohm switch position. In the 3-ohm switch position, there is a 2-μS delay. The AU-320 comes with gold-plated phono input sockets and a one-meter cord set with gold-plated phono plugs. The hum rejection of this transformer is also excellent.

Besides the usual listening panel evaluation of the Denon arm/cartridge combination, it was also used in a long-term, day-to-day listening evaluation in combination with the DP-6000 turntable. This setup exhibits sturdy, professional qualities which were easily apparent, as was its freedom from long-term listening fatigue effects. While some of the turntable's qualities, such as long-term speed stability of 0.002 percent and absolute speed accuracy regardless of changes in power line frequency, may not be required in a home music system, nevertheless it is an excellent turntable. Overall, the Denon DL-103D moving-coil cartridge, AU-320 transformer, DA-307 tonearm, and DP-6000 turntable is an excellent, albeit expensive combination, and can be highly recommended.

Edward M. Long