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Benchmark DAC1 USB

By Gary Galo, Regular Contributor

PHOTO 1: Front view of the Benchmark DAC1 USB. The nicely machined aluminum front panel is also available with a silver finish. The rack mount is optional.

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List Price: $1275.00

Benchmark Media Systems has developed an excellent reputation in the professional audio world for their microphone preamplifiers and digital conversion products. Unlike many "American" companies, Benchmark not only designs, but actually manufactures all of their products in the US, in the upstate New York city of Syracuse. Their DAC1 digital-to-analog converter has been available for at least four years, and has undergone some design refinements during that time. The DAC1 USB is the latest version of that product. (DAC1 Pre is the latest version).

FEATURES

The DAC1 USB is a two-channel, 192kHz, 24-bit DAC which has been designed with Benchmark's AdvancedUSB Audio Technology and UltraLock™ clock system. The headphone jacks are driven by Benchmark's HPA2™ headphone amplifier (the HPA2 is also used in Benchmark's H1 headphone amplifier).

The DAC1 USB has four digital inputs—S/PDIF via a BNC connector, a standard three-pin Neutrik gold-pin XLR connector for AES/EBU, and Toslink optical. What makes the DAC1 USB unique among outboard D/A converters is the inclusion of a USB connection. You can connect the DAC1 USB to any computer with a USB jack, allowing the user to bypass the mediocre sound cards found in most computers, using the DAC1 USB as the interface between the computer and monitoring system.

A three-position, spring-loaded front panel toggle switch, combined with three vertically mounted blue LEDs, is used for input switching. The switch simply toggles—up or down—through the various inputs. LED 1 indicates S/PDIF, 2 is AES/EBU, 3 is Toslink, and the USB input is indicated by *both* LEDs 1 and 3. As supplied, the DAC1 USB defaults to the USB input at power-up, but you can change the default input to any input by re-setting a jumper on the PC board. The input switching method is simple and well thought out.

The DAC1 USB has no power switch—the unit is intended to be left on at all times, or connected to a switched power line filter. If no digital input is detected for 15 seconds, the unit goes into standby and mutes the audio. The three blue LEDs are also used to indicate input status and errors. For example, 16 slow flashes indicate that no digital signal is present. An invalid sample is indicated by 64 rapid flashes.

When used with the three standard digital inputs, the DAC1 USB will operate at any input sampling frequency from below 32kHz to above 192kHz, at any word length up to 24-bits. The USB input functions at sampling rates up to 96kHz. You can connect variable-pitch digital sources directly to the Benchmark DAC without any external sample rate conversion. The DAC1 USB supports the Red Book de-emphasis function, at sampling frequencies up to 96kHz, making the unit truly backwards compatible.

The DAC1 USB has unbalanced RCA and balanced XLR line outputs. You can operate these either at a fixed, "calibrated" level or switch them to "variable," with output level set by the front-panel volume control. The "calibrated" levels are adjustable with 10-turn trimmers. In the variable position the DAC1 USB functions as a preamp line stage, allowing you to connect it directly to a power amplifier with the front-panel pot controlling volume. Users who need multiple line inputs may also consider the DAC1-PRE, which has an extra analog line input.

ADVANCED USB TECHNOLOGY

Benchmark devotes three pages of the instruction manual to discussion of their "Advanced USB Audio Technology." The DAC1 USB doesn't require any drivers in order to operate with Windows Vista/XP/2000 or Macintosh OS X. Digital data is transported from the computer source to the DAC1 USB in a bit-transparent fash-

ion, without any data modification, and without any need to re-configure software.

Previous native USB audio devices have been unable to stream audio at any resolution higher than 48kHz/16-bit. Benchmark's USB technology allows native USB audio at resolutions up to 96kHz/24-bit. The DAC1 USB will automatically operate with any sampling rate and bit depth being fed to it via the USB port, without reconfiguring drivers (there aren't any!) and software. Benchmark also buffers the USB datastream to prevent interruptions, which usually rear their ugly heads in the form of clicks and pops.

Benchmark notes that Windows 2000 and XP have a digital mixer known as a "Kmixer" (kernel audio mixer), which passes all audio before it reaches native USB devices. Kmixer contains a poor-quality sample rate converter, but Benchmark's USB technology allows Kmixer to default to a transparent mode, avoiding the sample rate conversion. Vista's sample rate converter is of excellent quality, and automatically defaults to the highest sample rate supported by the connected device. Nonetheless, you can defeat Vista's sample rate converter, if desired.

With 16-bit datastreams, the Windows volume control is bit-transparent only when set to full volume. But, Benchmark discovered that the Windows volume control is distortion free when streaming 24-bit datastreams. The DAC1 USB forces Kmixer to stream 24-bits so the Windows volume control doesn't degrade the audio quality. Benchmark also found that the Mac OS X volume control has poor quality sample rate conversion, and the system volume control degrades the audio unless it's set to maximum. OS X is capable of bit-transparent audio if the sample rate is manually set to match that of the audio being played, and the system volume control is set to 100% (use the volume control on the DAC1 USB). For more information on PC audio, go to www.benchmarkmedia.com/wiki.

JITTER CONCERNS

Benchmark is extremely concerned with the effects of clock jitter on audio performance. Better D/A converters, sample rate converters, and outboard jitter suppressors have generally employed two-stage phase-locked loops for improved jitter suppression, including my reference sample rate converter, a Parts Connection Assemblage D2D-1 (discontinued).

Benchmark claims that their UltraLock clock system exceeds the jitter performance of conventional two-stage PLL circuits.

The UltraLock system isolates the conversion clock from the digital audio interface clock, so jitter on any digital input can't have any measurable effect on conversion clock jitter. With this system, interface jitter will not degrade the conversion process. The DAC1 USB manual has an interesting and informative discussion of jitter, including two problems that are rarely discussed. One is that jitter causes phase modulation of the audio signal, producing unwanted sidebands on either side of every discrete tone in the audio signal. These sidebands are unrelated to the audio signal and are easy to hear and measure. Benchmark also says that jitter can severely degrade the digital anti-aliasing filters in an oversampling converter. Though seldom considered, they note that this effect is also easily measurable. The UltraLock system puts clock jitter below the measurement limit of the Audio Precision System 2.

DESIGN DETAILS

The DAC1 USB is not supplied with a schematic, but a look inside reveals most of the design details. Digital inputs are routed to an AK Semiconductor AKM4114 Digital Audio Interface, which includes the input receiver. The AKM4114 has eight digital inputs, and includes a low-jitter analog phase-locked loop with a lock range of 32kHz to 192kHz. The S/PDIF and AES/EBU inputs are each coupled with their own pulse transformer.

I don't see any evidence of input switching near the digital inputs—it appears that each input, including the Toslink and USB (after its own interfacing), is fed directly to one of the eight inputs on the AKM4114. This is very sensible, because the internal input switching of the AKM4114 probably results in lower clock jitter than external input switching. This capability is a compelling reason to use the AKM4114 for multiple digital inputs.

The I^2S output of the AKM4114 is fed to an Analog Devices AD1896 High Performance Asynchronous Sample Rate Converter. The AD1896 is the current flagship asynchronous converter chip from Analog Devices and boasts THD+N of -120dB and DNR (with filter) of -139dB. The AD1896 can convert any input sample frequency to any other, up to 192kHz. In the Benchmark DAC1 USB, the AD1896 is set up to convert all inputs to a sampling frequency of 110kHz, which Benchmark has found to be optimum.

The 110kHz output of the AD1896 is fed to Analog Devices' AD1853 DAC, a 24-bit stereo, multi-bit, Delta/Sigma converter chip operating at sampling frequencies up to 192kHz. De-emphasis, if needed, is performed in the AD1853. The DAC chip's differential current outputs are fed to 5532 dual op amps, which may seem an odd choice for current-to-voltage conversion these days. The DAC1 pre uses an LM4562 op amp throughout.

With a noise level of 5nV/√Hz, the 5532's low noise level and low cost still makes it attractive to some designers. Yet in other regards, particularly slew rate and bandwidth, there are many other chips that would seem more suitable for high-performance designs in 2008. The Burr-Brown/TI OPA627 has even lower noise than the 5532—4.5nV/√Hz, a slew rate of 55V/μS, and a gain-bandwidth product of 16MHz. By comparison, the 5532 has a slew rate of 9V/μS and a gain-bandwidth product of 10MHz.

Analog Devices recommends the OP275 for I/V conversion and differential-to-single-ended conversion on page 15 of the AD1853 datasheet. Benchmark seems to be using a topology similar to that recommended by AD. Another 5532 (one half per channel), rather than an OP275, also appears to be used for the differential-to-single-ended conversion (doubling as an output buffer). The analog filter in the AD datasheet is a Gaussian type with a -3dB point of 75kHz. I really don't understand why Benchmark chose a device as dated as the 5532 for use with a state-of-the-art DAC such as the AD1853.

(Note from the Manufacturer: The 5532s were chosen because, unlike most substitutes, they do not exhibit a rise in the THD with frequency above 20kHz. This prevents intermodulation distortion caused by ultrasonic audio content.)

The unbalanced outputs are driven by National Semiconductor LM4562 dual op amps, with a 5532 used as unity gain buffers for the two channels. Similar-

ly, the balanced outputs are also driven with LM4562s (one per channel, in this case), with a 5532 again used as the DC servo. Only one 5532 is used for both balanced output channels. I suspect that, for each channel, half of a 5532 is used as a servo amp around the first half of an LM4562, which feeds the second half of the LM4562 configured as inverting amplifier to form the other leg of the balanced output.

The LM4562 was designed as a high-performance audio device and boasts THD of 0.00003% into 600Ω loads. Slew rate is 20V/µs, gain-bandwidth product is 55MHz, and noise is exceptionally low at 2.7nV/√Hz. I would think that the LM4562 would also have been an excellent choice in the other places where Benchmark used the 5532.

The two headphone jacks appear to be driven by the same amplifier. The only difference is that one of the jacks can be configured to cut off the line outputs on the rear panel, while the other always leaves them on. The headphone amp has a pair of 5532 op amps and two Burr-Brown/TI BUF634 buffer amplifiers.

The BUF634 is an outstanding device capable of 250mA of output current, albeit with considerably more heatsinking than it's given in the DAC1 USB. Benchmark has used the five-lead DDPAK surface-mount package, with a small piece of ground-isolated PC land providing some additional heatsinking beyond the devices' own metal tab. For each channel, half of a 5532 provides the gain, buffered by a BUF634, with the other half of the 5532 operating as a DC servo amp.

(Note from Manufacturer: The PCB is designed as a heatsink. This is extremely effective, and can be shorted all day without overheating.)

Benchmark notes that the headphone amplifier design has an output impedance of 0Ω—the BUF634 is connected directly to the headset without the usual series resistors. Resistors will degrade the performance of any headphone amplifier; if the headphone does not have a flat impedance curve, the series resistor will change the headphone's frequency response. The amplifier will drive headphones with impedances as low as 30Ω, maintaining less than 0.00003% THD+N.

Fixed, three-terminal 7818A and 7918A regulators are used for the ±18V analog supplies (see Chuck Hansen's comments on supply voltages in the measurements portion of this review). Two digital regulators are also used, a 7805 for the 5V supply and an LM1085 for the 3.3V supply. Separate rectifier bridges are used for the analog and digital supplies, fed by separate windings on the toroidal power transformer. Most resistors and capacitors are surface-mount "chip" type, except for the electrolytics. The DAC1 USB doesn't contain any passive parts normally thought of as "audiophile" grade.

PERFORMANCE

Chuck Hansen's accompanying measurements show the DAC1 USB to be beyond reproach. Indeed, its measured performance taxes most available test equipment, short of an Audio Precision System 2. The System 2 is used in-house by Benchmark, and the manual contains their own set of measurements performed on the Audio Precision instrument.

Given the data collected by Chuck, there's no reason to doubt the outstanding measurements published by the manufacturer (Benchmark also includes jitter tests with their measurements). The printed manual supplied with the DAC1 USB is also available on Benchmark's website. I suggest downloading this version of the manual, because all illustrations and photos are in color.

I have been using the DAC1 USB in my office playback system at The Crane School of Music, SUNY Potsdam, for about two months. During the time I've had the DAC1 USB connected to my office system, I've heard dozens of my own Crane recordings on this DAC (most made with Schoepps MSTC-5 or MSTC-6 ORTF stereo microphones, a Millennia HV3B microphone preamplifier, and Tascam DV-RW1000HD digital recorders). All I can say is that I simply hear much more in my recording than before—more detail, improved low-level resolution, better dynamics, and a bigger soundstage with more precise localization.

I also installed the Benchmark DAC in my home audio system for a week, where I compared it to my recently purchased

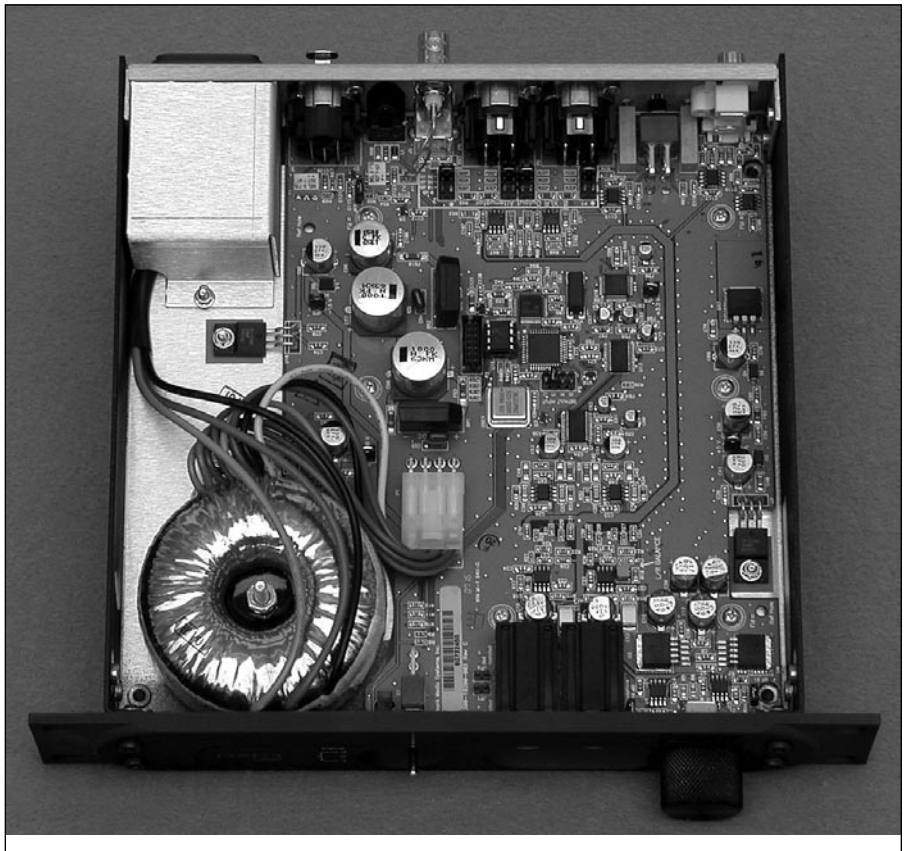

PHOTO 2: Inside the DAC1 USB. State-of-the-art digital chips are used, including Analog Devices AD1896 Sample Rate Converter and AD1853 D/A converter. Construction quality is excellent.

NAD M55 multi-format player used as a standalone device. The M55 also served as the transport for the DAC1 USB. I also compared the DAC1 USB to the Monarchy M24 (reviewed in Oct. 2007 with measurements by Chuck Hansen in June 2007).

The DAC1 USB is the most transparent DAC I've auditioned. CDs and DVDs are reproduced with pristine clarity. The sonic picture is detailed and spacious. Soundstaging is incredibly precise, with a large amount of hall ambience in the rear of the stage. On the Munch recording of Dukas' *The Sorcerer's Apprentice*, the violins playing harmonics at the beginning were reproduced with a delicacy that I've not heard previously on this recording.

The cymbals in Fritz Reiner's *Pictures at an Exhibition* are crisp and inner detail in *tutti* passages is exceptional. The Mercury recording of Respighi's *The Birds* is clean, detailed, and transparent. Strings articulation is excellent in both recordings. Precision is a word that continually comes to mind in listening to the DAC1 USB.

The Benchmark DAC was definitely designed with accuracy in mind, rather than euphony. In the Mercury recording of Respighi's *The Birds*, the NAD M55 as a standalone player sounds slightly warmer and sweeter, while the Benchmark sounds more analytical and more transparent. In the Classic Records DVD of Rachmaninoff's *Symphonic Dances*, the DAC1 USB sounds more transparent and more detailed, and the M55 again warmer and sweeter.

In the Reiner *Pictures*, the DAC1 USB is leaner, with the sonic picture reproduced with exceptional precision. This is especially true in the passage for the glissandi strings in "Gnomus" where the Benchmark's localization of each string section is more precisely focused than I've ever heard. Again, the M55 sounds warmer, with perhaps a bit more weight in the bottom octave.

In general, the comparisons I've made between the Benchmark DAC and the NAD M55 as a standalone also apply to the Benchmark versus the Monarchy M24. The Monarchy M24 was designed with a bit of euphonic coloration rather than absolute accuracy. The NAD M55 as a standalone player leans more toward the Monarchy M24 than the Benchmark.

I have only two criticisms of the DAC1 USB. Tonally, the Benchmark DAC is neutral except for a tendency toward brightness. Normally, the Benchmark DAC is never fatiguing, but the brightness doesn't always flatter already bright recordings such as Dorati's Mercury CD of Schoenberg's *Five Pieces for Orchestra*. The violin section in the Classic Records DVD of Stokowski's Everest recording of "Wotan's Farewell" from Wagner's *Die Walküre* is also brighter than I'd like, but the inner detail is also exceptional. It doesn't help that the Houston Symphony's strings were well below world-class standards in 1960.

Violin sections in orchestral recordings are not as sweet as the real thing. Given that the digital end of this DAC is practically beyond reproach, I can't help asking whether the DAC1 USB would sound even better if Benchmark would replace the 5532 op amps with another device. I think that the National Semiconductor LM4562 used for the analog output stages would be an improvement over the 5532 in other locations as well. That said, I would never have guessed, based on listening, that there were any 5532 op amps in this device had I not known better.

I've never heard a product with 5532 op amps sound this good. Could the Texas Instruments 5532 op amps be audibly superior to the types made by NJR and other Far East sources, and used in so many mid-fi products? Or, is the digital end *so* good that the use of 5532s isn't that detrimental? Still, I wonder what the Benchmark DAC would sound like with LM4562s used throughout.

Connecting the DAC1 USB to a computer couldn't be simpler. Plug it into a USB port and Windows will recognize it within seconds. Sonically, the difference between the Benchmark DAC and my computer sound card is astonishing. If you do a lot of digital editing, the ability to really hear what's on your editor will be most welcome. I have permanently installed the DAC1 USB with my computer editing system at work.

JITTER ELIMINATION?

I still use my Parts Connection D2D-1 Sample Rate Converter between the NAD M55 and Monarchy M24 DAC. Despite the dual phase-locked loop around the input receiver, and excellent jitter suppression properties of the built-in asynchronous sample rate converter, the D2D-1 has never eliminated sonic differences between various transports. My NAD M55 is the best-sounding transport (and the best-sounding standalone player) that I've owned. As a transport feeding the D2D-1, it is noticeably cleaner and more transparent than my older Onkyo DV-SP800 multi-format player, which, in turn, is better than the comparatively foggy Marantz PMD-340 CD player. As a transport, the Marantz sounds quite unrefined compared to the Onkyo and, especially, the NAD. Jitter is the only reasonable explanation for differences in the sound of various transports, and as good as the D2D-1 is, it must not be eliminating jitter, just reducing it.

Enter the DAC1 USB. My listening evaluations would indicate that Benchmark's claims for the jitter performance of the DAC1 USB are justified. I spent one evening comparing the NAD M55 and the Marantz PMD 340, with the NAD connected to the Benchmark's S/PDIF coax input (with D.H. Labs D-75 digital interconnect fitted with Canare 75Ω BNC connectors) and the Marantz connected to the AES/EBU input (D.H. Labs D-110 digital interconnect and

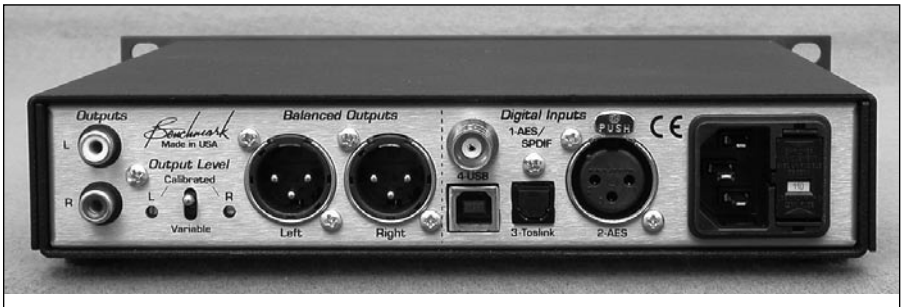

PHOTO 3: Rear view of the Benchmark DAC. S/PDIF, AES/EBU, and Toslink optical inputs are provided, along with a USB connection. Balanced and unbalanced analog outputs are also included.

Neutrik gold-pin XLR connectors). This made it easy to go back and forth between the two transports by simply switching the DAC1 USB's input selector and moving the reference CD to the other transport.

For the first time since I began evaluating digital hardware, I can honestly say that I found it difficult to tell the difference between two transports. The old, relatively unrefined Marantz sounded excellent connected to the DAC1 USB—spacious, detailed, and refined. There were times when I thought that the NAD M55 sounds slightly better—perhaps a shade better defined with the stereo image a bit more precise. Occasionally, I thought the Marantz sounded a bit mushy and the NAD crisper, the Marantz a little edgy in the treble and the NAD smoother. Then, I'd run another comparison and not be so sure of my conclusions.

The bottom line is that the Benchmark DAC reduces jitter to vanishingly low levels—measurably and audibly—to the point where even a transport that would normally not qualify as "audiophile" sounds excellent. If there are differences between my NAD and Marantz transports, those differences are very small, indeed. This is most impressive.

It almost goes without saying that any outboard jitter suppressor connected between your transport and the DAC1 USB is superfluous. I inserted my D2D-1 between the NAD M55 and the DAC1 USB to see whether this had any effect on the sound. I left the D2D-1 in the "Transparent" mode, so it was functioning strictly as a jitter suppressor, without any sample rate conversion. By simply swapping digital cables, it was easy to remove and re-connect the D2D-1.

The results were similar to comparison of transports, except this time I really was convinced that there was an audible difference, even though it was very subtle. The D2D-1 degraded the sound very slightly. It caused a slight loss of focus and detail and put a very subtle veil over the sound. It also softened the treble slightly. Benchmark has shown that it's possible to design a DAC so that external jitter suppression devices are no longer necessary or desirable.

CONCLUSIONS

The Benchmark DAC1 USB is an impressive achievement—an exceptionally refined DAC that offers remarkable performance at an extremely reasonable price. Benchmark's UltraLock circuitry sets new standards for jitter suppression, and the USB interface provides a significant improvement over monitoring via computer sound cards. Benchmark offers a 30-day, risk-free trial period. If you're in the market for an outboard DAC, you can't afford not to try one. *aX*

Manufacturer comments made by

Michio Aida
Advertising Director
Benchmark Media Systems, Inc.

TABLE 1 Reference Recordings

CDs

Dukas: *The Sorcerer's Apprentice.* Boston Symphony Orchestra conducted by Charles Munch. RCA Victor Living Stereo 68978-2.

Ravel: *Alborada del Gracioso.* L'Orchestre de la Suisse Romande conducted by Ernest Ansermet. London 433 717-2.

Rimsky-Korsakov: *Scheherezade,* Op. 35. Chicago Symphony Orchestra conducted by Fritz Reiner. RCA Victor Living Stereo 68568-2 (UV22-Encoded Limited Edition Gold CD version of 68168-2).

Mussorgsky/Ravel: *Pictures at an Exhibition,* especially track 2, "Gnomus." Chicago Symphony Orchestra conducted by Fritz Reiner. RCA Victor Living Stereo 68571-1 (UV22-Encoded Limited Edition Gold CD version of 61958-2).

Schoenberg: *Five Pieces for Orchestra,* Op. 16. London Symphony Orchestra conducted by Antal Dorati. Mercury Living Presence 432 006-2.

Respighi: *The Birds.* London Symphony Orchestra conducted by Antal Dorati. Mercury 432 007-2.

Wagner: *Der Ring des Nibelungen,* especially "Siegfried's Death and Funeral March" from Götterdämmerung (CD 4, Tr. 10-11), and the "Forging Scene" from *Siegfried* (CD 2, Tr. 3-5). Birgit Nilsson, Wolfgang Windgassen, et al. Vienna Philharmonic Orchestra conducted by Georg Solti. Decca 455 555-2.

DVDs

Rachmaninoff: *Symphonic Dances,* Op. 45. Dallas Symphony Orchestra conducted by Donald Johanos. Classic Records DAD 1004. (96kHz, 24-bit PCM transfer of 30-ips analog tape, or possibly a 15-ips copy, engineered by David Hancock).

Wagner: *Die Walküre*–Wotan's Farewell and Magic Fire Music. Houston Symphony Orchestra conducted by Leopold Stokowski. Classic Records HDAD 2029. (192kHz/24-bit DVD-Audio transfer of original Everest 35mm 3-track tape).