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Nakamichi's $11,000 DAT Recorder

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NAKAMICHI 1000 R-DAT RECORDER

Robert Harley

Two-chassis digital audio tape recorder (R-DAT format) consisting of separate tape transport and digital processor. Digital processor specifications: D/A converter section (44.1kHz sampling frequency): 8x-oversampling digital filter with dual 20-bit calibrated DAC. Frequency response: 5Hz–22kHz ±0.5dB. S/N Ratio: >106dB. Dynamic Range: >100dB. THD: 0.0005% (1kHz). THD+Noise: 0.0015% (1kHz). Channel separation: >106dB. A/D converter sections (after A/D and D/A conversion at 48kHz sampling frequency): Frequency response: 5Hz–22kHz ±0.5dB. S/N Ratio: >95dB. Dynamic range: >95dB, THD: 0.001% (1kHz). THD+Noise: 0.003% (1kHz); Channel separation: >85dB. Digital input: 75 ohm coaxial/EIAJ optical x3 (switchable). Digital output: 75 ohm coaxial/EIAJ optical x3 (switchable). Line input (balanced): 50mV (–18dB record level max)/40k ohms; unbalanced: 50mV (–18dB record level max)/25k ohms. Line output (balanced): 2V (0dB/100ohms) fixed, 2V max (0dB/100ohms) variable; unbalanced: 2V (0dB/1k ohm) fixed, 2V max (0dB/1k ohm) variable. Sampling frequencies: 32kHz, 44.1kHz, 48kHz. Dimensions: 17⅛" (435mm) W by 5¼" (133mm) H by 14⁹⁄₁₆" (370mm) D. Weight: 38 lbs 9oz (17.5kg).

Tape transport specifications: Sampling frequencies: 32kHz, 44.1kHz, 48kHz (32kHz and 44.1kHz digital input, 48kHz analog input). Tape speed: 8.15mm/s. Digital input: 75 ohm coaxial/optical (switchable). Digital output: 75 ohm coaxial/optical (parallel). Dimensions: 17⅛" (435mm) W by 5¼" (133) H by 14⁹⁄₁₆" (370mm) D. Weight: 35 lbs. 4oz (16kg).

Supplied accessories: full-function wireless remote control, aluminum transport cover, two digital coaxial cables, two digital optical cables, blank 120-minute DAT cassette, prerecorded DAT cassette, cleaning cassette, polishing cloth, batteries. Price (complete system): $11,000. Approximate number of dealers: 25. Manufacturer: Nakamichi America Corporation, 19701 South Vermont Avenue, Torrance, CA 90502. Tel: (213) 538-8150.

Think back for a moment to 1973. Richard Nixon was President, the Vietnam War was still raging, and cassette-deck technology was primitive, offering decidedly low-fi performance. Then, in a surprising move, a small company that supplied tape transports on an OEM basis to many well-known Japanese manufacturers but had never made a product under its own name, introduced a no-compromise cassette deck that defined the state of the art in cassette decks for the next decade. The Nakamichi 1000 cassette deck was born, and with it a new chapter in the history of high fidelity.

The Nakamichi 1000 cassette deck was a milestone in audio technology. It represented a complete rethinking of what could be achieved with a narrow tape running at 1⅞" per second. It was the first machine to use three heads, and achieved a then unheard-of frequency response of 35Hz–20kHz ±3dB. Even more surprising, however, this remarkable product was the first offering from a company whose name was unknown to American consumers. Mr. Niro Nakamichi, President, tried to sell the idea of a no-compromise tape machine to the manufacturers who used his OEM transports. When all the major companies rejected his idea, he decided to make his dream cassette deck and market it under his own name. Many industry observers thought Nakamichi was committing financial suicide: Who would buy a $1300 cassette deck to begin with? And from an unknown company?

We all know the rest of the story. The Nakamichi 1000 was extraordinarily successful, both technically and commercially. It explored the upper limits both of cassette performance and of what people were willing to pay for such performance. Nakamichi's timing couldn't have been better: the machine launched Nakamichi into the burgeoning cassette deck market just as this relatively new product category was about to explode. Suddenly, the Nakamichi name became synonymous with high-quality cassette decks. Since then, Nakamichi has expanded its product line to include CD players, amplifiers, and car stereo.

Nakamichi 1000 R-DAT transport

What does all this have to do with a new Digital Audio Tape recorder in 1989? Everything. The fact that Nakamichi's new DAT machine, like its legendary predecessor, bears the model designation 1000 reflects their attitude toward this new machine. Nakamichi feels the 1000 DAT recorder will set a benchmark of performance for many years, just as the 1000 cassette deck did over 15 years ago. The decision to invoke the 1000 moniker was not made lightly. According to Mr. Nakamichi, the 1000 name was chosen "after long and difficult deliberation."

There are many parallels between the 1000 cassette deck and the 1000 DAT recorder. Just as the original 1000 introduced a new level of technological sophistication to cassette technology, so does the new 1000 to DAT technology. The machine is loaded with design innovations that put it decidedly ahead of other DAT machines. Indeed, Nakamichi was the first DAT-machine manufacturer to offer for sale in the US a unit that could digitally record a 44.1kHz sampling-rate signal. There had been a tacit agreement that DAT machines would not have this capability, to prevent digital-to-digital copying of CDs. Despite threats of lawsuits by the RIAA (Recording Industry Association of America, a fervent anti-DAT group), Mr. Nakamichi felt that "intentionally crippling the capabilities of a machine like this was a compromise I simply couldn't make." Subsequently, however, an agreement was reached between DAT manufacturers and the record industry to allow 44.1kHz digital recording. In a break with the established DAT standard, the 1000 does not allow four-hour recording on a 120-minute tape. This is accomplished in other machines by reducing the sampling rate to 32kHz and quantization to 12-bit. Nakamichi felt the greatly reduced performance did not justify the extended playing time. The 1000 will, however, record a *digital* signal at 32kHz/12-bit from DBS (Direct Broadcast Satellite).

The Nakamichi 1000 Digital Audio Recording System consists of two chassis and a wireless remote control. One chassis, called the 1000p, contains the analog and digital processing circuitry, while the other houses the tape transport. Both units have identical dimensions and look very similar. Before discussing the construction and technical details, I must comment on the 1000's styling. It is striking. I have never seen an audio component that attracts the eye like the 1000. Finished in brushed aluminum with soft, rounded edges, the 1000 exudes a futuristic elegance.

Digital processor

The digital processor is the control center of the 1000 and the interface between the DAT transport and preamp. During playback, the processor receives a digital input from the transport and converts the multiplexed data stream to two analog outputs. While recording, it receives an analog or digital signal and outputs a digital signal to the transport for recording on a DAT cassette.

The processor can accept up to three digital inputs, selected from the front panel. Since all inputs use the industry standard S/PDIF (Sony/Philips Digital Interface Format), a CD player or second DAT machine with digital-out jack can be decoded by the 1000p. A dubbing switch provides copying between two of the digital inputs in either direction. This multiple-input feature with dubbing greatly increases the 1000's versatility. Owners can bypass their CD player's D/A converter and take advantage of the 1000's decoding section. In addition, it

Nakamichi 1000p digital processor and remote control

is a simple matter to copy from CD to DAT in the digital domain and monitor the signal without constantly changing the hookup.

Just above the input selector switches are an output level control and left and right input-level controls. A large knob at the far right is the master record-level control. These record-level controls function only when recording an analog input signal. When making a digital-to-digital copy, the DAT tape will have the same level recorded on the CD: from CD master tape to CD to DAT copy, ones and zeros are transferred unchanged, meaning that there is no change in level. The 1000 has vertical peak-reading meters toward the left side of the front panel. The meter's dynamic range is 60dB, with an overload indicator. A switch to the right of the meter turns the meter off, on, or selects a peak-hold function. Above the meter switch, another small switch selects emphasis on or off when recording. During playback, control bits in the DAT subcode automatically engage the de-emphasis circuitry if the recording was made with pre-emphasis. Because de-emphasis in the 1000 occurs in the digital domain, it should have better performance characteristics than analog de-emphasis circuitry. Pre-emphasis is a high-frequency boost applied to the signal before the A/D converter. A reciprocal curve is introduced in playback (de-emphasis) to restore flat response. Like emphasis in analog tape recording (NAB curve) and phono playback (RIAA equalization), emphasis in a digital system improves overall S/N ratio. The fourth and bottom switch in this row selects between the processor's analog and digital inputs.

Above this row of switches are four LEDs. One of them illuminates to indicate a preemphasised signal, the other three show sampling frequency. A headphone jack and headphone volume control are provided at the far left of the front panel beneath the power switch.

The 1000p features a modular design to accommodate future upgrades as A/D- and D/A-converter technology improves. The three main boards, D/A converter, A/D converter, and digital interface are easily removed from the rear of the chassis. The A/D board has balanced and unbalanced inputs, selected by a switch located between the output jacks. Similarly, balanced and unbalanced outputs are provided on the D/A board. In addition, the D/A board has one extra set of RCA outputs to provide both fixed and variable unbalanced outputs. The digital interface board has coaxial and optical inputs and outputs labeled DAT 1 and DAT 2. A third coaxial/optical digital input, labeled "source," is also provided. Finishing off the back panel are two unswitched AC outlets.

Construction quality is impeccable. The chassis is made from brushed aluminum as thick as $\frac{5}{16}$" in some places. A removable top panel is held by screws plated to match the exterior finish. Internally, solid copper and heavy copper plating are used extensively for electromag-

netic shielding.

In many products, one can get a feel for the designer's attitude by looking at small details the consumer would never see. Often, minor aspects of construction or design are compromised in the belief that they will not significantly affect performance or sales. On the other hand, some products reflect a dedication to quality and craftsmanship that extends far deeper than the consumer will ever notice. The Nakamichi 1000 definitely falls into this latter category. Some of these touches are described later in this review.

Tape transport

The Nakamichi 1000 Digital Audio Recorder, as the transport portion of the 1000 Digital Audio Recording System is known, records a digital signal input to it, usually from the 1000p digital processor. Its back panel has one digital input and output, selectable between optical and coaxial.

Looking at the transport's front panel, one immediately notices the clear window to the left of the cassette loading door. This window exposes the rotating head and transport mechanism. Everyone who comes in the test lab/listening room is fascinated by the tiny guides, loading arms, and head drum visible through the window. Nakamichi couldn't resist showing off their tape mechanism, which is unlike that of any other DAT machine. Users who prefer not to witness the machinations that bring them music can install a solid aluminum door (supplied) in the window's place.

The front panel's 43 (!) controls (buttons and switches, not including LED indicators) look intimidating at first glance. However, the controls are logically laid out; using them becomes second nature after a short time. The panel's far right side contains all the subcode programming features unique to the DAT format. The 1000's subcode programming facilities are quite sophisticated. During the pause between tracks, a code, called a "Start ID," is automatically written in the DAT subcode area. The Start ID identifies the beginning of a track for later search and random-access play. In a feature unique to the 1000, the user can select the threshold at which the Start ID is written, either −40dB or −60dB. Alternately, the automatic insertion of the start code can be turned off, allowing the user to write a Start ID code manually by pressing the "Write" button. If a Start ID code is mistakenly written, the "Erase" button removes it. Another Start ID feature, called "Renum," allows a Start ID number to be changed. If, for example, a CD is recorded with automatic insertion of the Start IDs but there is a segue between tracks five and six, all Start IDs after track six will be misnumbered. The manual "Write" feature, in conjunction with "Renum," can be used to correctly identify each track's beginning and number.

Similarly, the "Skip ID" write button will identify portions of the tape to be skipped during playback. A switch turns the skip function on and off. Like the Start ID code, Skip IDs can be erased and rewritten. Skip ID codes are particularly useful for playing back tapes of unattended radio broadcasts: commercials are easily identified and expunged. The Nakamichi 1000 has one other subcode programing feature I have seen on no other DAT machine: an end-of-tape marker. If an entire tape was not used in one recording session, the end-of-tape code makes finding where you left off easy. A "Search" button next to the End controls auto matically finds the End mark on the tape. In addition, the auto-rewind function can be triggered by an End marker. End codes can be written and erased manually. All the subcode functions described are accompanied by LED indicators to show what code is written where.

Just above the subcode programming section, a row of numbered buttons selects tracks for searching or random-access play. These buttons are very similar to a CD player's random-access controls. A numeric LED window displays search and random program-play status. All subcode functions and indicator LEDs are repeated on the infra-red remote control. Incidentally, the remote control is finished in the same brushed aluminum as the processor and transport, and has the same elegant feel.

The lower middle portion of the front panel houses the tape transport controls. These are all the functions one would expect on a tape machine (play, fast forward, etc.), with the addition of "F. Skip" and "R. Skip." The F. Skip and R. Skip controls shuttle the tape forward or backward to the first detected Start ID. Alternately, pressing this button twice causes the transport to search for the second start ID, three times for the third start ID, and so on. A source/tape switch is conveniently located next to the transport controls. This selector

switch is used just like a source/tape switch on a three-head analog tape machine for off-the-tape monitoring.

Extensive tape-counter facilities are provided. An LED numeric display above the transport controls can be switched between four counter modes: Counter, Program Time, Absolute Time, and Time Remaining. One of four LEDs illuminates to indicate which tape counter mode is selected. Program time and absolute time are dependent on that information being written in the subcode, while counter and time remaining are not. Time remaining, an extremely useful feature, is calculated from the differential hub speeds of the DAT cassette.

Finishing off the front panel are six LEDs that indicate sampling frequency, the presence of a copy-prohibit flag, emphasis, and whether the incoming digital data is acceptable for recording. A fader up/down rocker switch is provided for smooth fade-up at the beginning of a recording and fade-down at the end. The fader operates in the digital domain.

Digital processor: technical description

Like its namesake the Nakamichi 1000 cassette deck, the 1000 DAT recorder is packed with innovative electronic and mechanical designs that set it apart from other DAT recorders. It is clear that Nakamichi wanted to build a machine that would maintain its technological leadership for many years.

Let's start with the A/D section, a major source of sonic degradation in any digital audio system. One problem with A/D converters is called quantization error. During A/D conversion, a number representing the amplitude of the analog audio signal at sample time is assigned to each sample. With 16-bit linear quantization, the converter must select a number between 0 and 65,535 to represent the signal's amplitude. A problem arises because an audio signal's amplitude is infinitely variable and may fall between two quantization levels. The converter's digital output is thus an approximation of the actual amplitude. Further exacerbating this problem is the non-linear nature of A/D converters. The jumps between quantization steps are not evenly spaced, due to chip-manufacturing imperfections, causing further quantization error. This error is particularly noticeable at low levels as a "granulation" or "sandpaper" noise.

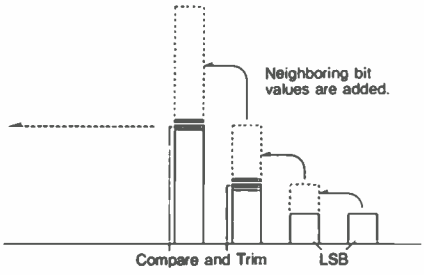

Fig.1 Nakamichi, A/D converter auto calibration

Nakamichi has taken an interesting approach to reducing this problem. The 2x-oversampling A/D converter has a self-calibration feature, activated every time the 1000p processor is turned on. The 1.4-second process calibrates the quantization increments between all 16 bits, resulting in reduced quantization error. The process is shown in fig.1. The values of the A/D converter's two Least Significant Bits (LSBs) are summed to produce the value of the neighboring bit. The summed reference value is then added to the value of the newly calibrated bit to produce the new reference for the neighboring bit. This process is repeated for the remaining bits. The result is uniform amplitude steps between quantization levels. Although the A/D converter performs 16-bit quantization, the auto calibration system is said to produce 18-bit resolution.

Because A/D (and D/A) converters change their characteristics with temperature, optimum performance is achieved only after the unit is warm and has reached thermal equilibrium. Consequently, the 1000's A/D auto calibration feature should be used after the unit has been on for at least an hour. Recalibrating the converter is accomplished simply by turning the power off, then on again. I was unable to see what converters were used because the chips are covered by metal shields.

The goal of reducing low-level quantization artifacts in the A/D converter is paralleled in the D/A section. All DACs have linearity errors that generally increase as signal level decreases. Linearity error is the difference between the actual amplitude of the recorded signal and the DAC output. This problem is particularly acute when the signal drops to such a low level that only the last few LSBs are toggled. Manufacturing tolerances create real performance differences, even among chips from the same batch.

To improve D/A conversion linearity, Nakamichi has come up with an interesting design. To keep low-level signals away from the LSBs on the DACs (where the greatest error is), each channel uses two D/A converters (actually, both portions of a Philips TDA1541 S1 Crown dual DAC). The first DAC receives the 14 Most Significant Bits (MSBs) from the 20-bit digital filter, while the second DAC receives the remaining 6 bits. These remaining 6 bits, containing low-level signal information normally subject to corruption by a DAC's linearity error, are instead input to the MSB inputs of the second DAC. This scheme keeps the signal on the upper bits of the DACs, where conversion is performed at a higher level of precision.

It is apparent that Nakamichi places a high priority on conversion linearity: the 1000 uses an additional method to reduce DAC linearity errors.

Each DAC is individually measured using a 22-bit, high-precision, scientific A/D converter. The measurements are repeated 10 times and the average linearity error values for each bit stored in a ROM (Read Only Memory) chip. The ROM chips are programmed with calibration data unique to each DAC. During D/A conversion, this information compensates for the DAC's intrinsic linearity errors. The gain of the second DAC that receives the 6 LSBs is also stored in ROM to smoothly merge with the main DAC's output. In theory, the 1000's D/A converter section should provide nearly perfect conversion linearity. The dual DAC with ROM compensation scheme is shown in fig.2.

The 1000's D/A section also incorporates a glitch-cancellation circuit. This circuit generates a timed, inverted pulse to cancel each predicted glitch.

On the question of whether audible degradation occurs even without a change in the digital code, Nakamichi firmly believes it does.[1] According to Nakamichi, jitter "can have a pronounced effect on sound quality." For this reason, the 1000 incorporates a circuit they call the "High-Precision, Twin-PLL Digital Audio Interface." According to Nakamichi, this circuit removes jitter components and controls the timing of the output signal.

On the analog side, component quality is very good, with oxygen-free polystyrene caps and metal-film resistors. The switching relays are nitrogen-filled, with two gold-plated contacts (one contact is redundant) to reduce the chance of a poor connection. In addition, the motion of the contacts wipes clean the connection every time it is engaged. This type of high-grade component is usually found in computers.

The power supply is quite hefty, with dual transformers and large filter caps. The three-pin voltage regulators have unusually large heatsinks. A copper plate that forms part of the inner chassis separates the power supply from the A/D, D/A, and digital interface boards. Overall, I was very impressed by the parts quality and solid construction of the 1000. It is as beautiful inside as outside.

I was, however, concerned to find Signetics NE5532 op-amps in the input and output sections, not discrete class-A circuitry. When so much attention has been lavished on this no-compromise machine, I thought it odd that op-amps had been chosen for the critical analog section. However, my feelings about op-amps may be unfounded: in my review of four integrated amplifiers in Vol.12 No.9, I preferred the sound of the Creek 4140 to that of the Audi-

1 See September's "Industry Update."

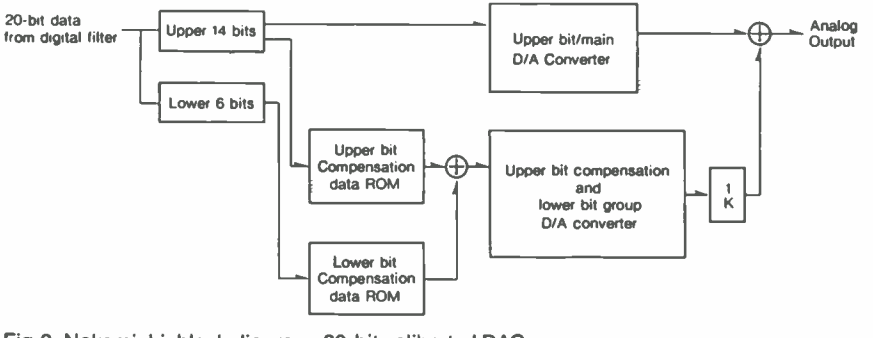

Fig.2 Nakamichi, block diagram, 20-bit calibrated DAC

olab 8000A. The latter uses discrete class-A amplification, while the Creek uses the 5532 op-amp. I have heard good and bad sound from both circuit types, and am beginning to think implementation may be more significant than the amplifying device.

The 1000's meters merit discussion. The dual 32-segment LED display is excellent, with wide dynamic range and fine resolution, especially at low signal levels. The selectable peak-hold feature is especially useful when setting recording levels. The overload indicator comes on when five successive samples are at maximum modulation.

Tape transport: technical description

Perhaps the most remarkable aspect of the Nakamichi 1000 is its radically different tape mechanism. Most DAT tape transports have been adapted from video-recorder technology, notably 8mm video. Nakamichi created a new transport from scratch, designed with digital audio recording in mind. This transport, called FAST (Fast Activated Stationary tape guide Transport), represents a significant improvement over video-based DAT tape-handling systems.

A video-based DAT transport, shown in fig.3, relies on incline guides on either side of the rotating head drum for aligning the position of the tape against the head. These guides move back and forth each time the tape is loaded against the head, increasing the chance of reduced positional accuracy. The FAST mechanism uses two stationary head-guide blocks for tape-to-head alignment, reducing the possibility of tape misalignment. Each guide block has three guide pins to establish the correct tape slant and height, and to absorb any deviation in loading-pin position. These pins are made from a proprietary, graphite-impregnated plastic.

The tape-loading arms differ significantly from video-based transports. In a conventional mechanism, the loading arms move at a constant, low speed. The 1000's loading arms move with varying force and speed, set to ideal levels during the tape-loading cycle. The loading arms move slowly to remove the tape from the cassette, speed up, then slow down before the pinch roller engages and the loading arms lock into place. These tape-loading functions are under microprocessor control, and the mechanism provides feedback to the microprocessor. The 1000's tape mechanism is shown in fig.4. Because of the clear window mentioned earlier, these motions are visible.

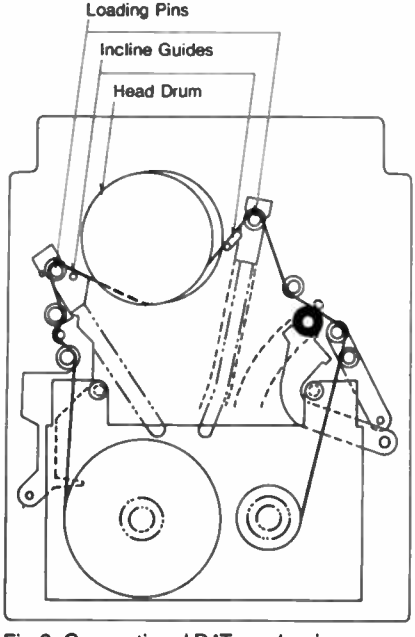

Fig.3 Conventional DAT mechanism

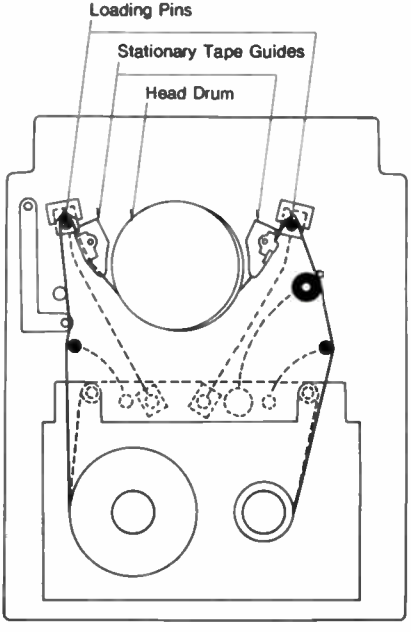

Fig.4 Nakamichi F.A.S.T. DAT mechanism

Another tape-transport feature unique to the 1000 is called the "Half Load Position." In a conventional transport, the tape is in contact with the head during fast-forward and rewind as it shuttles at 200 times normal speed. Tape-to-head contact is necessary during search functions, since the machine must read the subcode on the tape. Like all other DAT machines, the 1000 incorporates this feature, activated by pressing the fast-forward or rewind buttons. Unlike other machines, however, the 1000's Half Load Position lifts the tape away from the head drum, but does not retract fully into the cassette, during high-speed winding. If subcode searching is not needed, removing the tape from the heads makes sense since tape, head, and guide wear are reduced. Pushing the rewind or fast-forward button twice engages the half-load position. When in the half-load position, the wind time starts at 150 times normal speed, increases to nearly 600 times normal speed, then slows down to 150 times toward the end of the tape. When leader tape is detected, the reel-motor brakes are engaged to stop the tape. With the half-load feature, a two-hour DAT tape can be rewound in 19 seconds. Typically, DAT machines require between 45 and 60 seconds to fast-wind the same length of tape.

Finally, the 1000 incorporates a second pair of heads for off-the-tape monitoring. This is analogous to a three-head analog tape machine in which the third head plays back the information just written. This feature is known in professional digital audio recorders as "Read-After-Write" and is considered essential in demanding applications.

General impressions

I decided early on that putting the Nakamichi 1000 through its paces required recording live music. For a machine of the 1000's sophistication and capabilities, nothing less would reveal its intrinsic nature, both sonically and mechanically. When using a piece of audio equipment professionally, one develops a feel for the machine very quickly when it is asked to perform to a higher standard.

In addition to exercising the 1000 for this review, I wanted to record some music for the upcoming *Stereophile* sampler CD (probably available in the beginning of 1990). The disc will feature test signals and naturally miked acoustic music engineered by JA, JGH, and myself.[2] I will prepare the CD master tape using a MacIntosh computer, a large hard disk, and a digital editing package. Watch for a full report.

Fortunately, I met a local guitarist named Bruce Dunlap who was interested in doing a project. I went to hear him play at his regular gig and knew immediately that he would make a significant musical contribution to our CD. We decided to record Bruce's original music, written for acoustic guitar and acoustic bass. Finding a recording site was a challenge. The room needed to be large enough for natural reverberation, isolated from outside noise, have periods of time when no one was using it, *and* have a person in charge willing to turn it over to us. After some searching, we managed to line up a 140-year-old Santa Fe church, the Loretto Chapel. The Chapel is now part of the Best Western Inn at Loretto, about two blocks from the *Stereophile* offices. Its most interesting feature is called the "Miraculous Staircase," a spiral staircase built with no nails or supporting structure underneath it. The staircase, along with the ornate sculpture and carvings, provided a diffuse reverberation field.

The microphones were Tim de Paravicini's EAR tube mics, amplified to line level by his EAR 824M tube mic preamp. The Blumlein stereo microphone technique was chosen for its natural spatial perspective. This setup, also called "crossed figure-eights," puts two bidirectional mics at 90° relative to each other.

Monitoring on location has always posed problems. During the session, countless decisions are made, based solely on what is heard through the monitoring system. It must accurately reveal what the mics are hearing. Fortunately, I was able to use a pair of Stax Pro Lambda Signature headphones for the project. Their natural tonal balance, resolution, and portability make them ideal for remote recording.

We set up the recording system about 6pm and recorded until 2am on two successive nights. For about 12 hours of this time, I monitored the live mic feeds through the Staxes and listened to the real instruments in the room. This provided an ultimate reference when playing back the master tapes. More on the sound later.

2 During the review period, I transferred a number of my analog recordings that may be suitable for inclusion on this CD to DAT using the Nakamichi 1000. I can only agree with RH's feelings about what a joy the machine is to use. —JA

Functionally and ergonomically, the Nakamichi 1000 was a joy to use. Although numerous, its front panel controls are intuitive and very easy to learn. Within a short time, I felt completely at home with this machine. Its extensive subcode capabilities were particularly useful for marking the beginnings of takes and searching those points for playback to the musicians. The transport is exceptionally smooth and quiet, with no clunkiness when engaging fast-wind or play modes. In addition, the machine is very quiet during recording and playback, quiet enough, in fact, that I could sit just 15′ from the mics without introducing any extraneous noise. DAT machines usually have a "whirring" sound as the rapidly spinning heads (2000rpm) beat against the tape. According to Nakamichi, the 1000's lower noise level is indicative of the gentler tape-to-head contact made possible by their superior tape-alignment system.

The 1000 did experience one glitch, however. The Read-After-Write function did not work, preventing instantaneous off-tape monitoring. Subsequent attempts in the listening room to monitor from the tape confirmed that the sample was defective in this regard.

The sound

In addition to recording live music, I recorded some CDs on the 1000 in the digital domain. Theoretically, the recorded DAT (called a "clone" to imply its identical nature) should sound the same as the CD. Many people claim that a DAT recorded from a CD sounds different from the source. However, I could detect no difference between them.

During the recording session, the piece just recorded was played back for musical evaluation. I compared the sound of the 1000 (after it had been through A/D conversion, tape storage, and D/A conversion) to the sound of the microphones. I was surprised at how close the recorded sound was to the real thing. The primary difference was reduced reverberation, and less "air" around instruments. This phenomenon is typical of digital systems in general, and not unique to the 1000. Perhaps due to this loss of ambience, the soundstage lost some of its three-dimensionality. This reduced the palpability of the instruments and their spatial perspective in the natural reverberation of the church.

More important, however, the timbre of the guitar did not lose its warmth and delicacy. The 1000 did not add a metallic glare commonly induced by solid-state electronics and digital processing. The soft roundness that is the essence of the instrument remained uncorrupted. Bruce, the guitarist, was particularly pleased with the reproduced guitar sound. He is very sensitive to unnatural brightness on guitar heard on so many recordings but never from the instrument. His reference of what his guitar should sound like is far better than mine: he has spend years listening to the instrument compared with my 12 hours.

Back at the listening room, I prepared the 1000's digital decoder section for some head-to-head combat with the Digilog and my reference digital processor, the Theta DSPre. The playback system consisted of Vortex Screen loudspeakers driven by the Music Reference RM-9 tube power amplifier with a PS Audio 5.5 preamp used in the "Straightwire" mode exclusively, and Stax Lambda Professional Signature headphones.

My initial impression during the recording session of the 1000's smooth tonal balance was reinforced by extended listening. The top octaves were soft in comparison with the Digilog. I find that a laid-back treble presentation more accurately reflects the sound of real instruments. The Harmonia Mundi recording of Handel's *Water Music* is exceptionally free from glare and stridency, with totally natural timbres. If I hear glare when playing this recording, I know it is added by something in the playback system. This recording played through the 1000 revealed a tonal balance free from the stridency added by some other processors. In fact, I found the 1000 to be remarkably uncolored, especially in the midrange. In addition to the tonal balance of the guitar mentioned, vocals were particularly pleasing and unfatiguing.

The 1000's soundstage was open and detailed, with a nice bloom. Instruments were well-delineated within the soundstage, with a fairly good sense of depth. In this regard, however, it did not match the Digilog. The 1000 did not have the Digilog's transparent, "see-through" quality, but a slight haze that obscured the view *into* the soundstage. Instruments toward the rear of the soundstage tended to become homogenized, in contrast with the Digilog's ability to clearly present detail in its correct spatial perspective.

Bass reproduction tended to be richer and

more rhythmically satisfying through the 1000 than through the Digilog. Both processors had excellent bass dynamics, but the Digilog sounded slightly leaner in the midbass.

When comparing the Theta with other processors, as I've done in other reviews, I am always amazed by the leap in musicality offered by the Theta. This review is no exception. While the 1000's digital processor is good, it was no match for the Theta in terms of soundstaging, liquidity, and sheer enjoyment of music.

In short, the 1000 has a polite treble and neutral tonal balance, but falls short of the state of the art of digital decoding due to its lack of transparency and slight veiling. This combination of characteristics tends to reduce musical satisfaction, but does not grate on the nerves the way overly bright or tonally colored products do.

Measurements

I was particularly eager to measure the Nakamichi 1000's D/A converter linearity, since they took such great pains to reduce linearity error. I was not surprised, therefore, to discover that the 1000 had the lowest linearity error I have measured. Fig.5 shows the plot made from playing the "fade to noise with dither" track on the CBS test disc. It is as near to a perfect straight line as I have seen. Fig.6 shows deviation in dB from perfect linearity. Looking at these data in tabular form, the 1000 had an error of 0.13dB at –70dB, 0.41dB at –80dB, and 1.6dB at –90dB. Compare this with the linearity performance of the Digilog and Black Box 2 (Vol.12 No.10) which, like the 1000, use the Philips TDA1541 DAC.

The noise-spectrum graph made by playing a low-level signal was equally impressive. Fig.7 shows a 1kHz tone at –90dB, and the noise spectrum. This is the best performance I have measured. The –120dB level at 60Hz is particularly impressive, indicating good power-supply isolation. The small positive linearity error indicated by the 1kHz peak crossing above the –90dB horizontal line can also be seen in fig.6.

The measured frequency response was ostensibly flat throughout the audio band apart from a slight rolloff in the top octave, being down 0.5dB at 20kHz. This conforms with the printed specifications.

Conclusion

The Nakamichi 1000 Digital Audio Recording System is a technological *tour de force* and a significant milestone in home recording. Never before have home recordists had access to such a sophisticated digital recording system, usually reserved for professionals. The level of thinking that went into the 1000's design and construction puts it vastly ahead of other DAT machines. In addition, the "feel" of the 1000 is superb: it exudes a sense of luxury and elegance.

I must now deal with the 1000's $11,000 price tag. A "Buy Recommendation" in *Stereophile* implies that the reviewer not only likes the product, but feels it offers sufficient value to warrant purchasing it himself. Based on these criteria, I can recommend the Nakamichi 1000 to anyone who takes recording seriously. Quite apart from the machine's extraordinary construction, extensive capabilities, innovative technology, reasonably good sonics, and beautiful styling, Nakamichi has made a product that will undoubtedly stand the test of time.

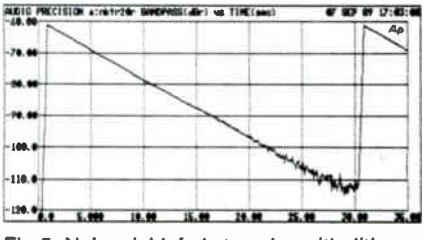

Fig.5 Nakamichi, fade to noise with dither

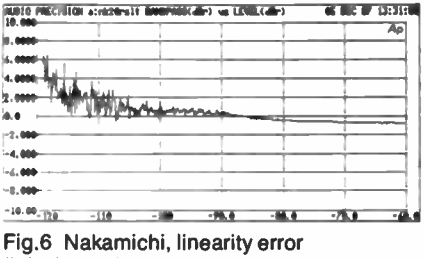

Fig.6 Nakamichi, linearity error (left channel

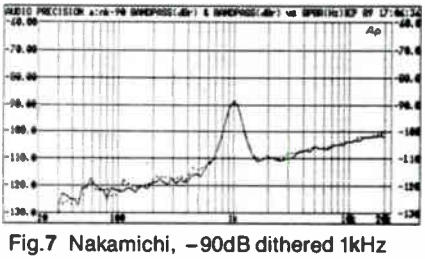

Fig.7 Nakamichi, –90dB dithered 1kHz tone with spuriae and noise

When weighing value, longevity is surely an important factor in the equation. The highly advanced tape mechanism, futuristic styling, and modular construction of the processor and tape transport (allowing upgrades as converter technology improves) were clearly designed to keep the 1000 contemporary many years from now. In addition, the 1000's multiple-input digital processor can replace the D/A section of an existing CD player, further enhancing its value.

Potential buyers should be aware, however, that the 1000 does not represent the very best sound quality available in digital decoding. Although its sonics are above average and very listenable, the 1000 falls short of the musical performance offered by such Class A units as the Theta.

Questions have been raised about the viability of the DAT format. Will DAT outlive the Nakamichi 1000? My opinion is that DAT is here to stay. Moreover, the professional recording community has embraced DAT with a passion. The format offers a relatively low-cost digital recording system with performance that equals and often excels systems costing ten times the price. The DAT format may even replace the industry-standard ¾" U-Matic cassette for CD mastering.[3]

The Nakamichi 1000 clearly represents the state of the art in home recording. Its innovative technology and designed-in longevity make it a worthy successor to the Nakamichi 1000 cassette deck which inspired it, both in concept and in name. **S**

3 See AES preprint #2770 (0-5), "Recording, Editing and CD Mastering Entirely in the DAT Format," by Robert Harley and Ray Keating, presented at the 86th AES convention in Hamburg, West Germany, March 1989.

THE WAVEFORM LOUDSPEAKER

Larry Archibald

Four-way, bi-amplified, moving-coil–driver loudspeaker, with electronic crossover. One 15" JBL subwoofer, two 6", long-throw, fiber/plastic-laminate woofers, one 1" textile-dome tweeter, one ribbon super-tweeter. Crossover frequencies: 150Hz, 3kHz, 9kHz. Crossover slopes (from bottom up): 18dB/octave, 18dB/octave, 12dB/octave. Sensitivity: 90dB/1W/1m. Recommended amplifier power: up to 500W, depending on room size (two stereo amps required). Maximum output: unspecified, but "110–120dB" is mentioned—which gives you an idea of what to expect. Frequency response: 28Hz–20kHz, ±2dB. Dimensions: 31" W by 21" D by 47" H. Weight: approximately 180 lbs each. Price: $9800/pair. Approximate number of dealers: 2 in US, 3 in Canada. Manufacturer: Waveform Research, Inc., R.R. #4, Brighton, Ontario K0K 1H0, Canada. Tel: (613) 475-3633.

John Ötvös, the father of Waveform Research Inc. and The Waveform Loudspeaker, hesitates not at inviting ultracritical examination: "The Waveform is the most accurate, the best, forward-firing loudspeaker in the world." Period. Reviewers, of course, welcome such statements, and I'll be examining that one, but I'll also try to answer the inherent reviewing question of whether the Waveform is a good place for you to park $9800 on your way to "the highest of high-end sound" (that was our slogan for the first Santa Monica High End Hi-Fi Show).

The company

Without a doubt, one of the first questions I'd ask myself is whether the company asking for my $9800 had proved itself in the high-end wars—what were the chances that my dealer would still be selling this expensive product two years from now, or, more ultimately, that this little-known speaker company would still exist?

Given the small number of US outlets for the Waveform (Absolute Audio in Orange County and Keith Yates Audio in Sacramento), the former question might well be answered simply by interviewing the dealers involved. Though their powers of prediction aren't perfect, I'm sure you could get an idea just by talking to Evelyn Sinclair or Keith Yates. And, of course, *Stereophile* reviewers aren't given to clairvoyance as to the survival of companies, though we'd like that ability—some of the products we've rated most highly have been produced by people just starting out who've