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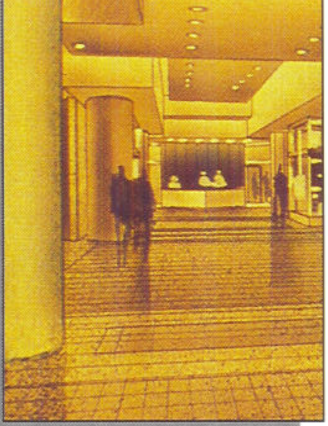
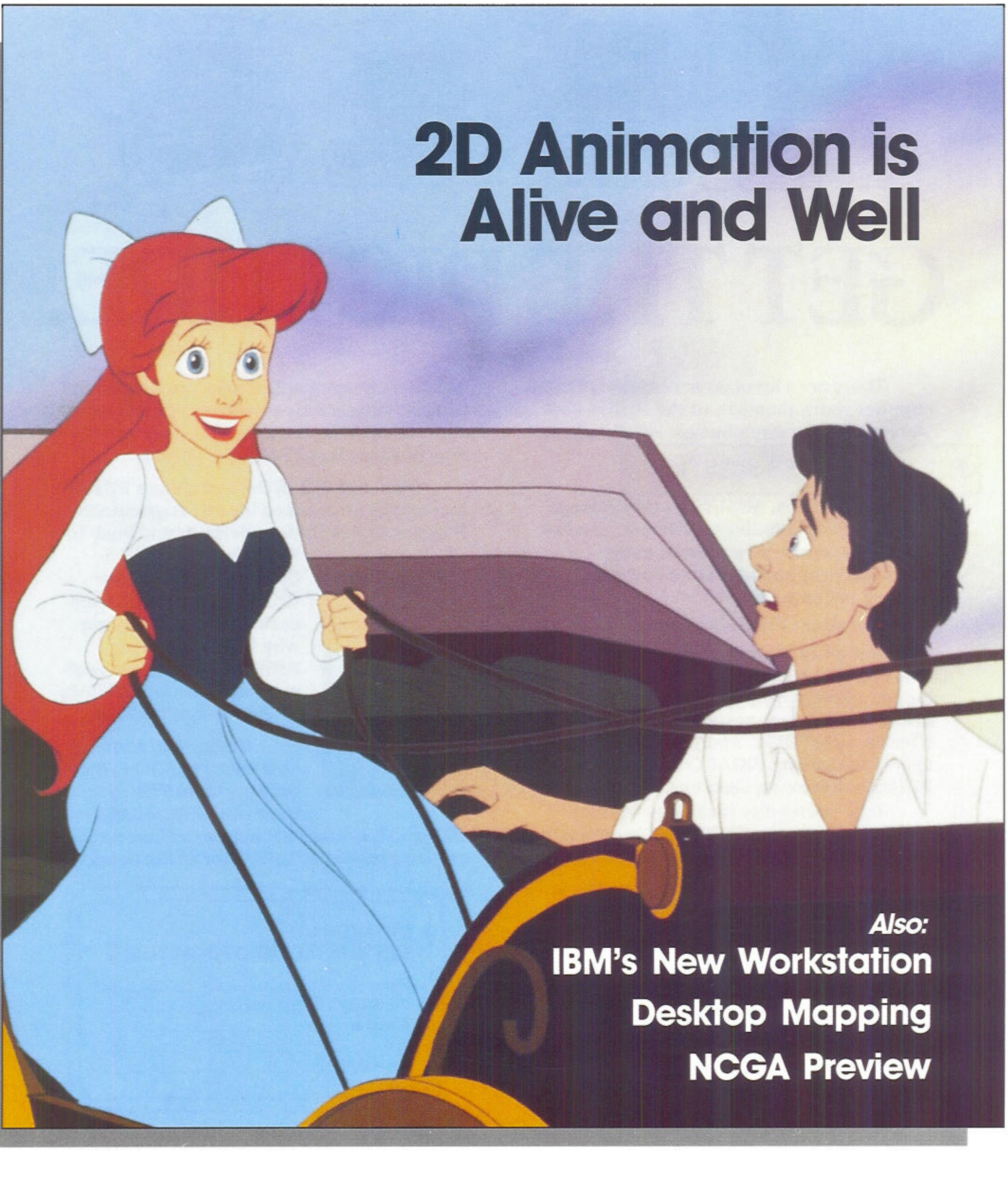
COMPUTER GRAPHICS WORLD



As architects beef up their presentations with graphics, they often find their design process changes as well, p. 52.



COMPUTER GRAPHICS WORLD MARCH 1990 VOLUME 13, NUMBER 3

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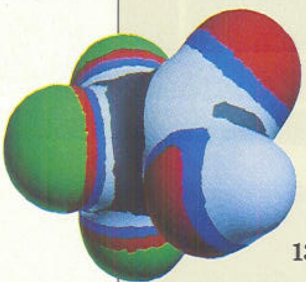
COVER: Computer graphics is now making inroads into such classical animated films as Walt Disney's "The Little Mermaid." In fact, a number of elements, including Prince Eric's carriage, shown here, were animated with computers. For more about the film and its use of computer graphics, see Front End, page 6.

COLUMNS & DEPARTMENTS



FOCUS: Trends in Animation

Dental CAD/CAM

Dentists are using new techniques to model and mill crowns

By Andrew McIntosh

Imagine going into the dentist's office to have a crown made for a tooth. You anticipate a rather lengthy and uncomfortable experience spanning two visits. Instead, you emerge from the office about an hour later, wearing a permanent crown, custom-designed, milled, and cemented in place—all in just one visit. No putty-like impression to gag on. No temporary restoration to be put in and pried out a week later. No inconvenient second visit with another injection of anesthesia.

At the rate that new computer-aided restoration technology is being developed, such painless dentistry could become common in the next few years. In fact, functional systems are already being sold and used in the US and Europe.

CAD/CAM in dentistry is rapid and accurate and uses an entirely different methodology from traditional techniques for dental restoration. It also involves an entirely new way of using prosthetic materials—milling prestructured materials instead of casting restorations out of melted metal or fired porcelain. In the decades ahead, this technology could indeed make contemporary dental techniques obsolete.

Dental CAD/CAM is more convenient for the patient and more productive for the dentist. He or she can now produce up to 20 crowns per day—instead of the five most dentists can produce—with greater accuracy than is possible with conventional techniques.

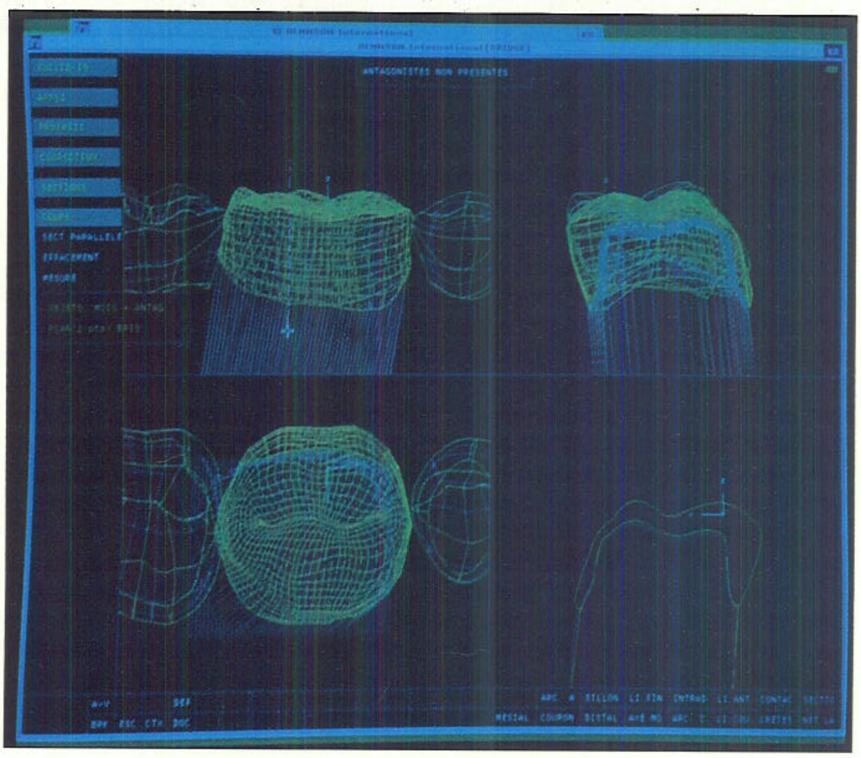
The Duret-Hennson System, developed and used in France, recently made its US debut at the University of Southern California School of Dentistry. It was installed in August 1989 and will begin serving dental students and their patients this summer. Commercial units are expected to be available this year in the Los Angeles area.

Professor Jack Preston, DDS, co-director of the school's section of dental imaging, predicts that the system will transform the school's methodology and curriculum.

"As far as we know," says Preston, "there is absolutely nothing out there as fully developed, as flexible, or as complete as the Duret-Hennson system. It does inlays and three-unit bridges as well as crowns. It makes the part of the crown that fits into the tooth as well as the outside—the biting surface."

So far, the USC School of Dentistry has the only fully operational Duret-Hennson System in the

CAD crown: The Duret-Hennson CAD workstation shows both the crown restoration (yellow) and the prepared tooth (blue). A cross-section of the crown appears at the lower right.



Andrew McIntosh is a Boston-based freelance writer who covers high technology.

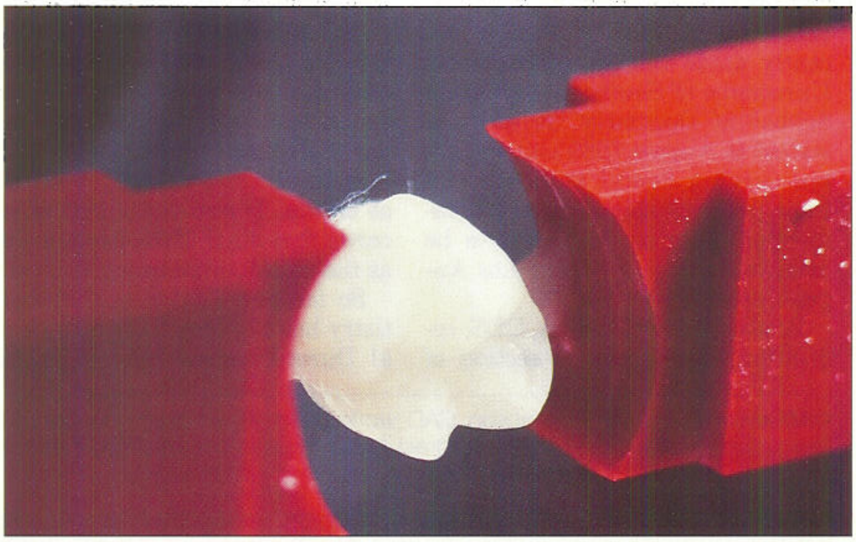
US. Although the school will continue to offer courses in traditional dentistry, the curriculum will begin to emphasize the use of CAD/CAM in dentistry of the future.

Much of Preston's time these days is spent conducting intensive evaluations of the system with Dr. Francois Duret, the system's inventor. USC has a unique agreement with Hennson International (Viennes, France), which backed development of the system and manufactures the equipment for it. Hennson's choice of the USC School of Dentistry for the system's first US installation was based on long-standing mutual trust and respect between Duret and Preston. "There were academic considerations, too," says Preston. "The USC School of Dentistry enjoys a reputation for technological concepts and unique research projects."

This year, in their first exposure to the technology, seniors will take a series of lectures on CAD/CAM. Upcoming seniors will have two electives: a course on CAD/CAM using the system, and another on general clinical applications of computers. In 1991, the school will offer its first mandatory core course—computer applications with strong emphasis on CAD/CAM. This lecture and lab course will target first- and second-year students who have not yet had clinical experience.

Preston expects the system to get FDA approval shortly. "We've had no problems or difficulties with our Duret-Hennson. It's performing very well, doing everything we've asked it to do."

The Duret-Hennson system consists of three major components: an imaging workstation, a CAD workstation, and a CAM workstation. The imaging workstation, a proprietary system that captures and correlates images of the restoration area, consists of a laser imaging probe and a processor. According to Jean-Claude Haas, president of Hennson International, standard 850-by-560-pixel color monitors are available for the workstation. The probe, a camera-like device, has a CCD (charge-coupled device) that digitizes images before transmission via standard RS-232 cable to the next stage—CAD.



Milling molars: This upper first molar appears at the end of the milling process. It is now ready for removal from the material block. In this case, the crown is made from a new material called Aristee.

Each time an image is made, transmitted to, and recorded in the processor, it is translated back into an analog image for simultaneous display on a color monitor. This allows preliminary image manipulation to be done interactively. The processor correlates the images, taken from different angles, to build a 3D image, which is transmitted to the CAD workstation.

The CAD workstation creates a computer model of the impression and displays it on the monitor, enabling the dentist to design the prosthesis interactively. A VAX 3100 from Digital Equipment Corp. (Maynard, MA) drives the workstation, which—as modified for the dental school—runs a special software program developed by Duret for research-oriented tasks. According to Haas, practically all design is done using a mouse for point-and-shoot interaction with a menu on the screen of a 1024-by-856-pixel monitor.

When the design is complete, a standard hardwired cable transmits the data to the CAM workstation, which automatically mills the prosthesis. A proprietary, five-axis micro-milling machine, the CAM workstation gets its numerical-control toolpath instructions from the computer model created in the CAD stage.

Naturally, all this complex processing requires a good deal of memory—800K for imaging just one impression. With 80M of memory in its CAD-stage processor, the Duret-Hennson system stores up to 400 crowns.

Dentists may be surprised to discover that the Duret-Hennson system is more like an alert, well-informed, and helpful colleague than a number-crunching computer. It makes suggestions, verifies judgments, and helps dentists model and modify crowns, all the while deferring to the dentist's opinions.

A dentist would begin the process by preparing the tooth, reducing it by a drill (or burr, as dentists call it), and making it ready for the crown. The tooth may then be sprayed with a coating of white, non-toxic material to improve image quality and prevent the tooth from reflecting or absorbing too much light. Special reference clamps, similar to rubber dam clamps, are also placed around the tooth to help correlate views.

The dentist inserts the hand-held laser optical probe into the patient's mouth. Holding it in various positions, the dentist makes eight to 10 images from different angles, targeting all surfaces of the prepared tooth. Images of the patient biting down would also be taken to check the fit of the crown against other teeth.

Each time the dentist wishes to make an image, he or she steps on a foot pedal, and the image, captured by laser probe, appears instantly on the monitor. Using a mouse and tablet, the dentist can add information regarding adjacent teeth and boundaries into which the crown is to be made. By aligning the reference clamps, the workstation then correlates all the views of the tooth to build a 3D image.

Tooth Library

The image is then ready for transmission to the CAD workstation. At the CAD stage, the dentist selects a standard crown from a library of teeth. The workstation combines this tooth with the imaging data and offers a proposed restoration. The dentist then modifies the proposal for the individual parameters and other factors already entered into the system. He or she can either accept the computer's offering, or further modify it for aesthetic reasons or greater precision. Once the dentist is satisfied with the final design, it can be transmitted to the CAM station. At this point, the dentist's work is essentially done—the NC milling machine takes over.

"The conventional method restricts the materials to ones that can be cast," says Haas. "Now we can use materials that can be milled," he adds. In addition to the conventional ceramic materials, the Duret-Hennson system can also mill new metals, such as titanium, and other new ceramic composites, such as Aristee and Dicor.

Before dental CAD/CAM, dentists had to make a physical impression of the prepared tooth, together with adjacent and opposing teeth, using an elastic material. The impression was used at the dental lab to obtain a hard stone model or die, which was then trimmed and manipulated. A pattern was created in wax on the die for insertion into a refractory mold. The wax was then burned out or eliminated by heat, and metal or porcelain cast into the mold to create the crown. It took 45 minutes of lab time just for the stone to set.

With the traditional method, patients were fitted with temporary restorations to be worn for a week or so, then removed during a second visit, when the crown was per-

manently cemented in place.

"In the typical 30-year professional life ahead of our current graduates," says Preston, "computers will drive most clinical applications. Our curriculum will have to reflect this fact, so that students will be trained and ready for a future dominated by CAD/CAM.

"We want to prepare future dentists not just to use the new technology but also to teach it to those already in practice, so that when an associateship is established, it can be more symbiotic. The senior member will provide the recent graduate with a practice, a knowledge base, and management experience in dealing with patients. The new associate will contribute information on how to use the new system," Preston explains.

Preston anticipates that students will learn the system faster than practicing dentists because today's students have grown up with computers. The real challenge, he believes, will be in convincing established dentists, some of whom, after 20 to 30 years in practice, may not be ready to invest the time and money to go into CAD/CAM.

Preston adds that the price of a system—projected to be about $200,000 for the Duret-Hennson configuration at the dental school—must be weighed against the resulting time/cost savings and increased production. The dentist can produce two to four times as many crowns in a day, and he gains a full appointment—more time to produce more units. Still, considering initial system costs, Preston foresees one-man private practices giving way to group practices clustered around a centrally located technology center and sharing computer costs. These costs will inevitably decrease as CAD/CAM applications multiply.

Duret sees a bright future for the technology he helped to pioneer: "Increasingly, CAD/CAM in dentistry will influence the direction of clinical practice and research at universities." However, with dental CAD/CAM, as with any science, Duret admits, "Results achieved must be analyzed with caution." *CGW*

A World of Effects

By Audrey Vasilopoulos

More and more frequently, high-end video special effects facilities are turning to digital-based production and post production equipment. Simply put, digital-based systems, although more expensive than their analog counterparts, provide compositors, editors, and animators with the ability to enhance, manipulate, composite in several layers, edit, and reproduce live-action video sequences, graphics, and stills, with no image degradation. With analog equipment, on the other hand, multi-layer compositing and other special effects techniques frequently result in generation loss in the completed video production.

"Oh No, Not Them!": Complex special effects techniques were used to create this show opener, which dissolves from live action to clay animation and then reverts back to live action.

The benefits afforded by digital-based equipment prove especially important to Planet Blue (Hollywood, CA), a high-end special effects and post production house, in the development of high-quality effects for its clients. One of Planet Blue's most recent projects was the development of the opening for the new Fox Television series "Oh No, Not Them."

The show opener, which dissolves from live video to clay animation and then reverts back to live video, involved the use of com-