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QUEST - QUEUEING EVENT SIMULATION TOOL

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ABSTRACT

QUEST® (QUeueing Event Simulation Tool) is a 3D, physically-based simulation tool used to analyze industrial and service-related environments. QUEST is a hybrid discrete event simulation tool, which enables both object-oriented as well as simulation language approaches to modeling. With this powerful feature, QUEST not only takes advantage of the ease-of-use and rapid model developing capabilities of object-oriented modeling but also provides the depth and extendibility of language-based behavior modeling. This presentation will first discuss QUEST's approach to model building, system analysis, and its output capabilities. It will conclude with the ever-expanding role of integration, customization and visualization in the discrete event market and how QUEST addresses these concepts.

1 QUEST

QUEST uses a physically motivated approach to simulation modeling. Each resource is intuitively described as it exists in the real world. These resources are then visually connected to describe the flow of parts or information. Built-in logic options are written in a high-level procedural language that is provided for rapid model creation. All of these routing and processing options are available for user modification. Full scale, 3D geometry can be imported through a wide range of CAD translators or created in the integrated CAD system provided with QUEST. Models can be executed with or without animation and changes can be made interactively during a run session. Models may also be executed in a batch mode. Access is provided to a full range of analysis features including bottleneck identification, confidence interval calculations, optimization algorithms, and custom summaries for resource allocation and system performance.

2 MODEL BUILDING

2.1 Menu System

QUEST's patented* three-tier menu system provides a mouse-driven interface through which every function is no more than two mouse clicks away. The three tiers of buttons are conceptually referred to as Contexts, Pages, and Actions. There are 10 contexts in QUEST shown across the top of the screen. Each context has a group of up to six (6) pages associated with it. Under each Page there are several action buttons that perform specific functions. For example, the Model Context has a Workcell Page that has a Create Workcell Action button. These buttons are highlighted in the sample model shown in Figure 1.

2.2 CAD Interface

QUEST includes a full-function 3D CAD system that allows users to quickly create geometry to represent even the most detailed system. QUEST also has a wide range of data translators for combining geometry from many different CAD packages into the same environment. Direct translators are available for IGES, DXF, Catia, Pro/ENGINEER, Unigraphics, Stereolithography, and STEP.

2.3 Basic Modeling Entities

QUEST models are constructed through the combination of a few basic entities. These include Widgets, Sources, Sinks, Workcells, Labor, and Buffers. Each of these entities has characteristics and default logic options that facilitate rapid model construction.

Sources and Sinks are used to describe the arrival and departure of Widgets from the model. They are used to specify inter-arrival times, lot sizes, and product mix for the system being modeled.

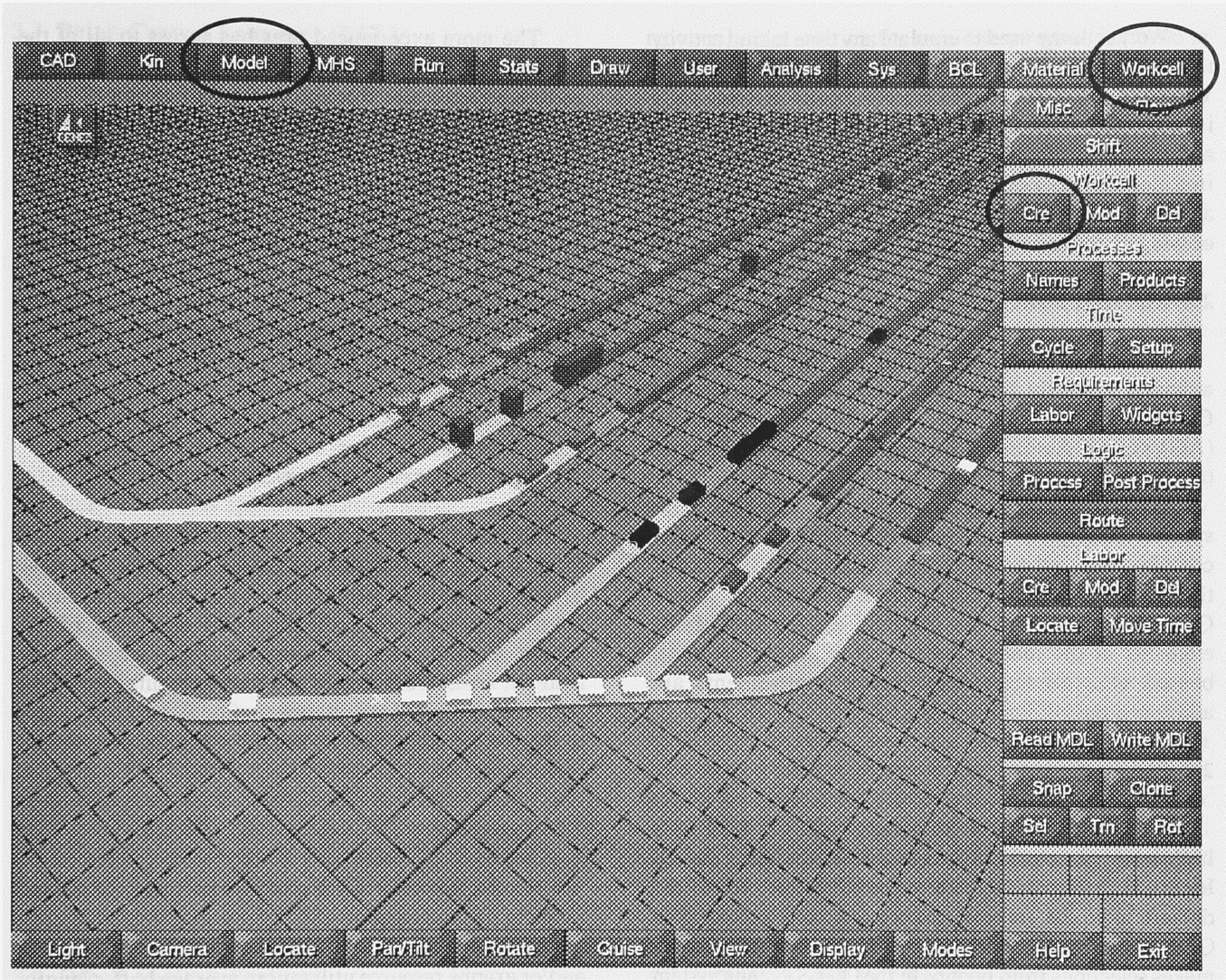

Figure 1: QUEST Menu System

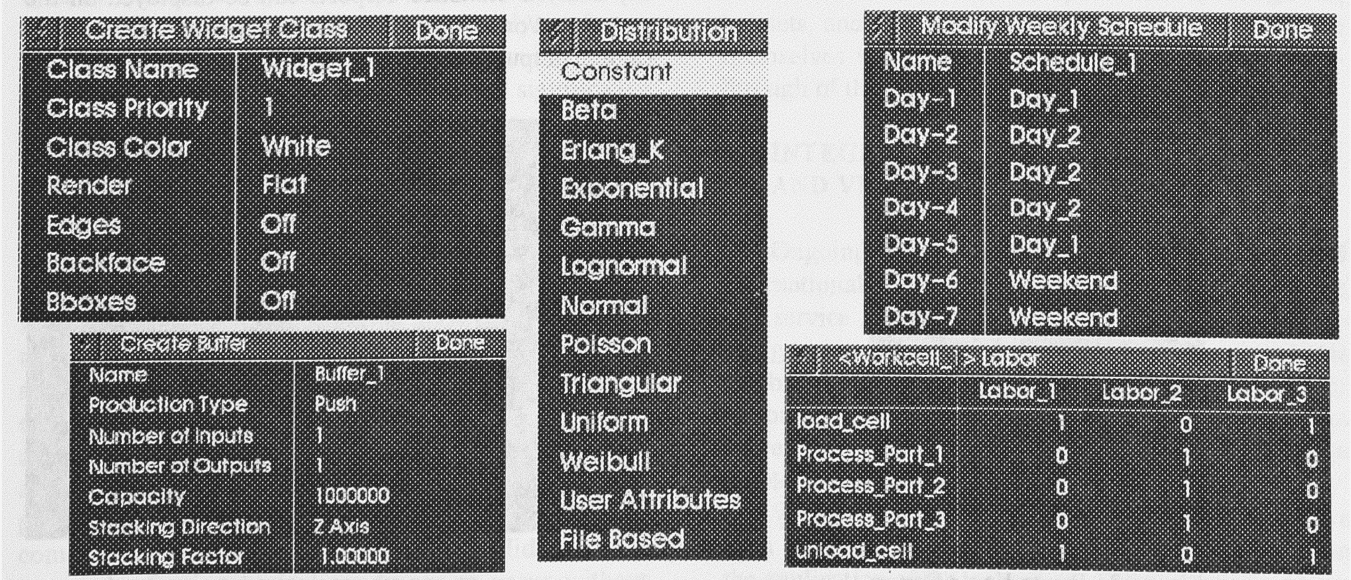

Figure 2: Model Creation Popups

Workcells are used to emulate any time taking activity in the system. They can require any combination of Widgets and Labor to perform a task. Built-in Route logic is also provided to handle most common routing algorithms. Buffers are used for modeling storage areas in a model. Buffer capacity can be set and default logic is also provided to allow for LIFO, FIFO and special sorting of widgets in the buffer.

2.4 Material Handling

In addition to the basic entities, QUEST also provides advance material handling constructs for modeling Conveyors, Power and Free, Automatic Guided Vehicles (AGVs), and Automatic Storage and Retrieval Systems (AS/RS).

Each of these entities has unique characteristics specially designed to allow for the modeling of large, complex material handling systems without the loss of the natural flow of material and information. Since QUEST is based on the physical dimensions of the elements of the model, the impact of aisles, columns, beams, etc., on the storage space requirements are addressed during the modeling.

2.5 SCL

Simulation Control Language (SCL) is QUEST's high-level procedure language that is the basis for all logical considerations made while modeling. All of the default logic for routing, processing, and queueing in QUEST has been written in SCL. The novice user simply makes selections from popups in the QUEST menu system to model the majority of common situations. An example route logic popup is shown in Figure 3.

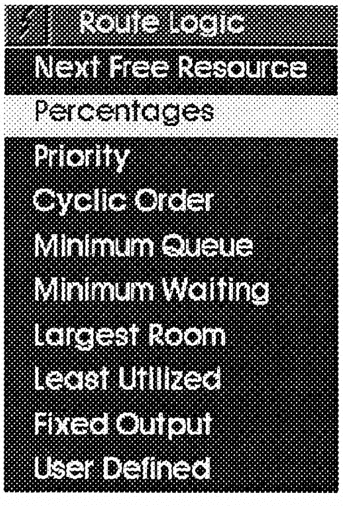

Figure 3: Route Logic Popup

The more experienced user has access to all of the built-in SCL logic. Unique modeling situations can be addressed naturally through the modification of these procedures. These changes can be kept in a common area for use by many users or separated based on the individual using the system. For model development, SCL has interactive tracing features and a real-time debugger.

For more advanced applications, SCL also supports the creation of user popups, the assignment of data structures, and a suite of UNIX socket commands for communication with everything from an external 'C' program to shop floor PLCs.

3 SYSTEM ANALYSIS

3.1 Activity Based Costing (ABC)

QUEST provides a full activity based costing system for analyzing not only the difference in production rates between proposed alternatives but also how those alternatives will effect the financial operation of the system. Capital costs, inventory holding costs, and raw material costs are a few of the cost attributes provided with the system. Several international currencies are supported including Dollar, Yen, Lira, Marks, Pounds and Francs.

3.2 Reporting

Graphs, bar charts, pie charts, histograms, dynamic strip charts, and custom ASCII file output reports can be created through QUEST. The system automatically tracks and/or graphs resource utilization, average buffer length, widget throughput time, resource production rates, bottleneck identification based on utilization, and other key analysis statistics. Reports can be displayed on the screen and/or sent to a file for viewing at a later time. A sample output graph is shown in Figure 4.

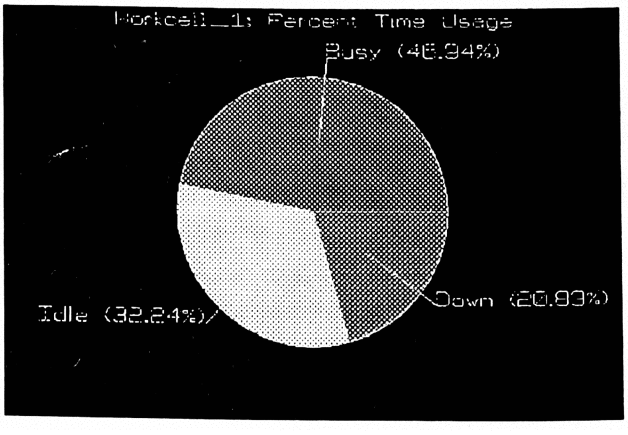

Figure 4: Output Graph

3.3 Batch Control Language (BCL)

Batch Control Language (BCL) is a powerful command and control system for operating QUEST. It can be used from either inside or outside the QUEST menu system.

Inside the QUEST menu system, BCL offers an alternative to the point-and-click approach through macro buttons and text commands. 'SET' commands, for instance, can be used to set everything from the cycle time of a workcell to the viewing angle of the model. BCL commands can also be called conditionally by SCL. Applications of this connectivity include variable speed conveyors and user-interactive facility tours.

Outside the QUEST menu system, BCL can be used in two different modes; stream and socket. In both cases, the QUEST window appears without menus. The stream mode allows a text file to be used as input and can direct output to an output file. For example:

```
quest -b < batch_file > output_file
```

Under the stream mode, any UNIX socket may be directed to QUEST. The socket mode allows any external program, residing on any machine in a TCP/IP network, to invoke and communicate with QUEST using BCL commands and return codes. In this way, user applications may systematically create QUEST models, conduct experiments, and optimize simulation parameters in a third party interface written in 'C', Visual Basic, or any other callable language.

3.4 Other Analysis Features

As successive runs are executed during a given QUEST session, the system keeps track of all previously mentioned statistics for comparative analysis. Batch reports are automatically generated for analyzing trends. Buttons are provided for inquiring statistical significance at a user-defined confidence level. Data sets can also be stored and retrieved for analysis at a later time. QUEST has an unlimited number of random number streams and users have the ability to change not only stream values but also seed values for any stream in the system.

QUEST also provides many interactive visual analysis tools. Status highlighting allows the user to see the state a resource is in based on its color. Users can save specific views of the model and the viewing window can be split into up to four (4) different views. Visually accurate conveyor accumulation and buffer stacking gives an exact look at the physical state of a facility at any point during a simulation. QUEST's unique incremental compilation allows for fast interactive validation of a system by forcing logical conditions to occur without recompiling or waiting for an entire program scenario to finish.

4 OUTPUT

In addition to model building and system analysis features, QUEST also has a rich set of output capabilities for communicating ideas, problems, and results. These features include dimensioned output drawings, color hardcopy output support, direct video creation support, custom ASCII file generation, and Virtual Reality interfaces.

4.1 Draw World

QUEST has a fully integrated 2D draw world that can be used to generate dimensioned drawings directly on standard size CAD borders. Companies can include their standard title blocks and send plots directly to HPGL, TIFF, and color PostScript output devices.

4.2 Video

QUEST supports the creation of 3D animation files for TIFF, RLE, HPGL, and color PostScript images. These files can be created automatically for every simulation update and stored for processing and editing at a later time. QUEST supports the sending of a video signal directly to a VCR and system calling features to access the audio capabilities emerging in many of the new hardware platforms.

4.3 Virtual Reality Interfaces

QUEST supports the latest in Virtual Reality devices. Drivers are available for FakeSpace Booms, data gloves, helmets, and stereographic goggles. Users can immerse themselves into their model and take a virtual walk-through of the facility before any capital is invested.

5 INTEGRATION, CUSTOMIZATION AND VISUALIZATION

Ongoing pressures in terms of price, quality, and international alternatives have caused the manufacturing and service sectors to continue to look for ways to do things better, faster, and cheaper. These pressures combined with today's powerful and affordable computer options are causing companies to turn to simulation to solve design, implementation, and reconfiguration problems early in the product development cycle.

While the merits of discrete event simulation have been heralded for decades, problems have persisted in the application of the technology. Software vendors have

concentrated on ease-of-use, flexibility, and product functionality rather than the more important issue of how simulation can become part of the overall corporate decision making process. To this end, QUEST extends the traditional definition of discrete event simulation to include integration, customization, and visualization. Integration — to allow for the use of existing data and extension of simulation models through the entire life cycle of a product, service, or facility. Customization — to provide increased time savings in the process of building and analyzing systems. Visualization — to not only effectively communicate ideas and concepts to management but also to serve as a design tool during critical stages of a project.

5.1 Integration

QUEST has many characteristics that make it an integral part of the product data management system. They include bidirectional CAD translators, open architecture, a wide choice of platforms, and object-based hierarchical links to robot and CNC simulation packages.

QUEST has a wide range of CAD translators; IGES, DXF, Catia, Pro/ENGINEER, Unigraphics, STEP, CGS, and VDA. QUEST also includes tools for data reduction, automatic polygon generation, and 3D geometric construction from 2D drawings. QUEST can also generate fully-dimensioned HPGL and PostScript plots and export data back to the corporate CAD system.

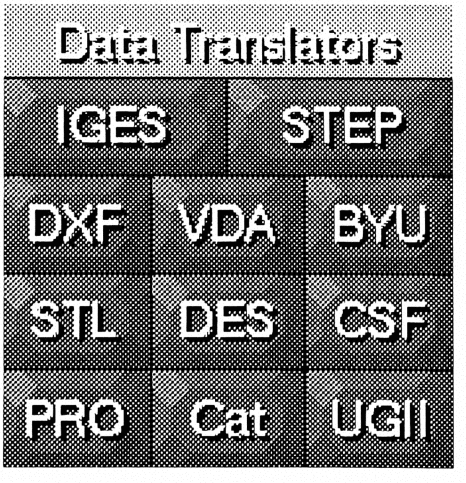

Figure 5: CAD Translators

Open architecture is another key component to integration. External programs can communicate with QUEST using integrated TCP/IP socket commands. QUEST also relies on accepted graphics standards for its development core and therefore supports a wide variety of platforms. Platforms currently supported include IBM-compatible PCs, Silicon Graphics, Sun, Hewlett-Packard, Intergraph, IBM 6000 and DEC. Heterogeneous network versions of the software are available.

Moving toward the goal of integrated virtual factory, QUEST is a part of the suite of products offered by Deneb Robotics. Other products include IGRIP for off-line programming of robotic cells and Virtual NC for the validation of CNC programs using the actual G and M codes for specific CNC controllers. QUEST can not only directly exchange geometry and real-time information with these programs but also send and receive signals from Programmable Logic Controllers (PLCs), robots, and machine tools on the factory floor.

5.2 Customization

As simulation becomes increasingly prevalent, more and more novice simulation users are being asked to model, if not analyze, their environment. Quite often the scope of the modeling tasks is narrow and repetitive. This is where an adaptable, customizable software package can save time and make the model building process more understandable. QUEST's object-based environment, user-definable environment, and SCL application capabilities help customize simulation for each user.

The object-based nature of QUEST models allows them to be merged or divided based on the needs of the modeler without any programming. This means models can be built in pieces by several people and merged without fear of strict naming conventions. It also means that if a portion of a model appears in a new system, it can be extracted and plugged into the new model. This saves time and naturally cuts down on the complexity of most models.

QUEST also allows the user great freedom in defining the appearance and content of his/her environment. Background colors, text size, fonts, left handed menus, foreign language support, and user specific data libraries are a few of the over 50 items that can be customized.

The most powerful customization feature in QUEST is SCL application development. Users can create their own menu buttons, use their own terminology, create popups to define their own user interface, and even change the logic routines that QUEST calls for all of its routing and processing functions.

5.3 Visualization

In order for the results and concepts put forth by a simulation to be readily applied in corporate decision making, managers and customers need to be comfortable with more than the methods, assumptions, and data used to model the system. They need to understand why a design is flawed and why specific changes will improve

the system. Numbers and statistics are only part of that understanding. Visualizing a proposed idea reassures the viewer that the appropriate level of detail was used in modeling and allows for a more comfortable environment to discuss the pros and cons of any situation.

QUEST uses full-scale 3D geometry, a sophisticated lighting and shading model, texture maps, and virtual reality to provide everything from a high level conceptual flow model to a detailed, photo-realistic, virtual walk-through of a proposed facility. An example of a texture-mapped workcell is shown in Figure 6.

6 SUMMARY

From the input of actual factory schedules and the importing of existing CAD data, through the generation of custom output reporting and direct communication with factory floor PLCs, QUEST's real world approach integrates simulation into the corporate decision making process and makes the modeling process more intuitive.

QUEST's ability to create custom user applications in an easy-to-use, object-based environment provides the expanding simulation market the visualization necessary to make informed, collective decisions without sacrificing accuracy and efficiency

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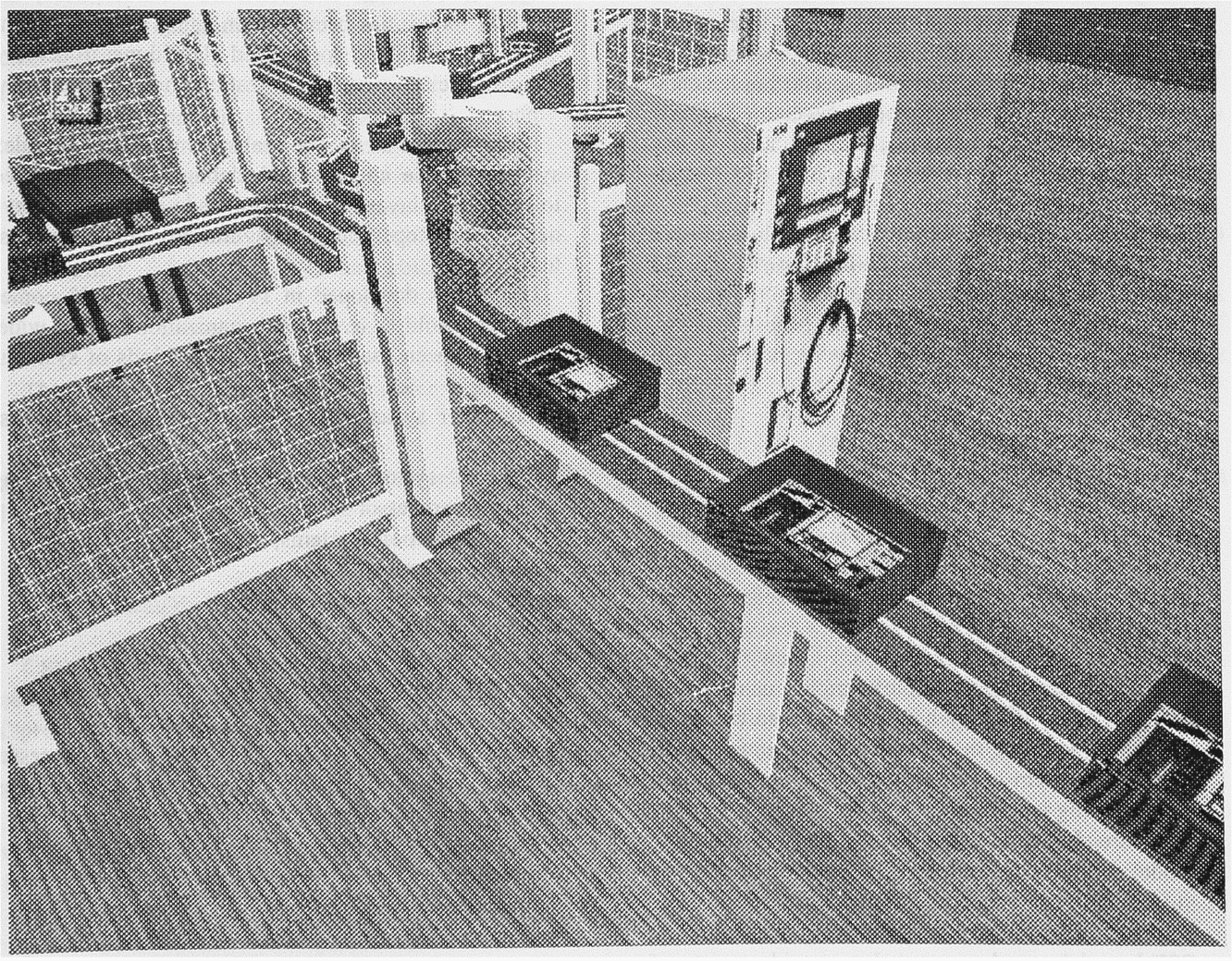

Figure 6: Texture-Mapped Model