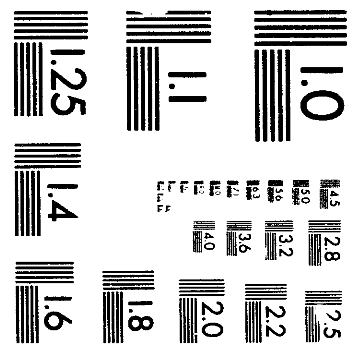

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Blasting, Graphical Interfaces and Unix*

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Abstract

A discrete element computer program, DMC (Distinct Motion Code) was developed to simulate blast-induced rock motion. To simplify the complex task of entering material and explosive design parameters as well as bench configuration, a full-featured graphical interface has been developed. DMC is currently executed on both Sun SPARCstation 2 and Sun SPARCstation 10 platforms and routinely used to model bench and crater blasting problems.

This paper will document the design and development of the full-featured interface to DMC. The development of the interface will be tracked through the various stages, highlighting the adjustments made to allow the necessary parameters to be entered in terms and units that field blasters understand. The paper also discusses a novel way of entering non-integer numbers and the techniques necessary to display blasting parameters in an understandable visual manner. A video presentation will demonstrate the graphics interface and explains its use.

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The History of DMC

The largest mining operations in the U.S. are surface coal mines which involve processing and movement of significant amounts of rock and soil to extract the coal and reclaim the land. The surface coal mining industry has adopted a blasting technique called *Cast Blasting* which allows the movement of a maximum amount of overburden material with explosives. This leaves less material to be handled with mechanical equipment such as draglines and trucks and makes the operation more efficient. Sandia has worked closely with ICI Explosives, USA to develop methods for computer modeling of coal mine bench blasting which includes cast blasting.

The Sandia computer program, DMC (Distinct Motion Code), is a discrete element code that uses spherical elements and explicit time integration to track particle motion resulting from a blast. A unique feature of DMC is the coupling of the rock motion calculation with a gas flow capability. The code models the flow of the explosive gases outward from the blastwell assuming the rock is a porous medium. Spherical element loads are calculated using the gas flow characteristics, and the porosity of the gas flow model is modified as the discrete elements move. Input to this model includes rock properties, geometrical configuration and explosive equation-of-state parameters. This enables the user to have a wide range of control over blast design parameters. DMC is currently implemented on a SUN SPARCstation 10-41 computer workstation manufactured by Sun Microsystems Incorporated.

Moving from a Mainframe

The original version of DMC was hosted on a Cray XMP or YMP. In 1990 it was decided to move DMC to a physically smaller machine. The first option tried was a PC 386 running Unix. This machine did not have sufficient computational speed. The second, and most satisfactory, option was a Sun Sparc II platform. This platform had sufficient computing power to allow problems to be solved in overnight runs and offered superior graphics to the PC.

The Need for an Interface

DMC and the spherical element model generator, ROCKMESH, employ a keyword input format. The keyword input is friendly enough for the developers but is somewhat cryptic for normal blast designers. The keyword input also does not include interactive graphics, forcing the user to modify the input, run the program and then examine the results of the current data set. A user friendly interface was needed so that blasting and mining engineers could easily perform blasting simulations. The Sun platform, that provided the necessary computational power, also featured Open Windows which is a graphical interface with the Unix operating system. A separate program for constructing custom interfaces was also available. This combination made it possible to develop a custom graphical user interface.

Graphical User Interface

The Graphical User Interface (GUI) has it roots in the Xerox PARC project that is now familiar to the computer industry. The workstation graphical facilities allow entry and display of the parameters necessary to execute complicated programs such as DMC. The workstation does the tedious work of input formatting. The user is presented a graphical, easy to understand display where parameters can be entered in familiar terms. This graphics environment has the benefit of reducing software mastery time and minimizing formatting errors.

The construction of a GUI requires an understanding by the implementor of the units and standard parameters that require processing. The interface employs metric units to be compatible with DMC. The implementor should understand the machine used to develop the interface as well as the standards which guide the interface architecture.

At one time there were two competing graphics standards for GUI's on Unix based workstations. Motif developed by the Open System Foundation (OSF) which has recently become the sole standard for GUIs in this market, and Open Look from Unix International (UI), which until recently was implemented as Open Windows on Sun platforms. The DMC interface is written in the Open Look standard.

Requirements document

A requirements document was written as the first step in interface development. This document defined the required interface input and specified logical groupings of parameters into popup screens. This document had several shortcomings and did not address a number of issues which, in hind sight, should have been specified. The human side of the interface was not very well addressed. Such important issues as color and location of associated variables and consistency between screens were not addressed in sufficient detail.

Development of the Interface

The next step in interface development was creation of a prototype version using the *Sun Open Windows Development Guide Version 1* (Guide-1). This was done to convince ourselves and management that a graphical interface could be developed for DMC. Guide-1 has a built-in prototyping feature that allows demonstration of important interface features. The prototype was developed in a week. The results were positive and decision was made to proceed. The first version of the interface, constructed from the prototype, was called the integer interface because it employed integer sliders. Popups were designed to allow the entry of materials and explosives, each of which could be used as building blocks to create the final model. The materials are the rock types in which the blast is to take place. The explosive popup reads parameters for equation-of-state definition, density, equilibrium pressure, ect. Entry of blast geometry was designed as a series of popups to describe the actual bench or crater blast. The user was guided though the process by linking popup windows in a logical manner.

The interface rapidly soared in size to thousands of lines of C code. The integer interface was built on the integer slider widgets that are a part of Guide-1. The integer interface required that the user convert real numbers into integers for slider input. This feature made the interface cumbersome to use which was not foreseen when the requirements document was developed. A major rewrite of the interface was required to ease the entry of floating point numbers.

The new entry method provided the ability to enter floating point numbers by typing them in (string entry) or by using sliders. Figure 1 shows the popup for floating point entry. This floating point popup allows the user to set the position of the decimal point in a string of numbers and allows entry of a sign for the number, an exponent and a sign for the exponent. The floating point popup can be enabled from the interface wherever a real number is required. The user is presented a button as well as a text field for floating point entries. Pressing the button causes the floating point entry popup to appear or the user can type in the string. Either is accepted by the interface and the number is entered into the calculation. The development of the floating point popup and its use was a major advance in making the interface easier to use.

A second major version of the interface, based on the use of floating point entry, was developed. This version of the interface was written with the later version of *Sun Open Windows*

Development Guide Version 3 which includes several improvements over Guide-1.

The integer interface also did not allow for different geologic layers. This second version included the ability to describe a layered medium for the blast. The layered medium is defined by a set of popups that allow specification of either horizontal or vertical layers of different materials.

An Example from the Interface

The bench row popup provides an example illustrating how the interface collects user input. Figure 2 shows the row entry popup. The problem name and row identifier messages at the top of the popup provide reference information about the problem being described.The burden floating point entry button and text allow the user to enter a floating point number describing the burden in the current row. Stemming height, spacing, hole depth and hole diameter are entered in a similar manner. Figure 3 illustrates the various quantities. Hole angle is an integer slider which allows entry of the hole angle in degrees. Similar integer sliders are provided for hole and row delays. The explosive for the row is selected from a multi-selection box which lists all of the explosives known to the blasting system. Finally, the buttons across the middle of the popup allow the user to move between row descriptions or end the row entry process. The text area below the control section serves as a record of previously entered rows. When the blast entry is complete the user is presented with three illustrations which show the simulated blast. One view shows the face, the second shows a view of the bench and spoil configuration and the larger view shows the bench configuration. Figure 4 illustrates a typical graphic. The video tape which accompanies this paper provides a more complete example.

The Future

The interface will continue to evolve as industry uses DMC and requests new features. The next addition will allow definition of explosive columns which have inert material decks. Another upgrade which will be required is conversion of the interface to the Motif standard since Sun has announced they will no longer support Open Look in favor of the now industry-standard Motif.

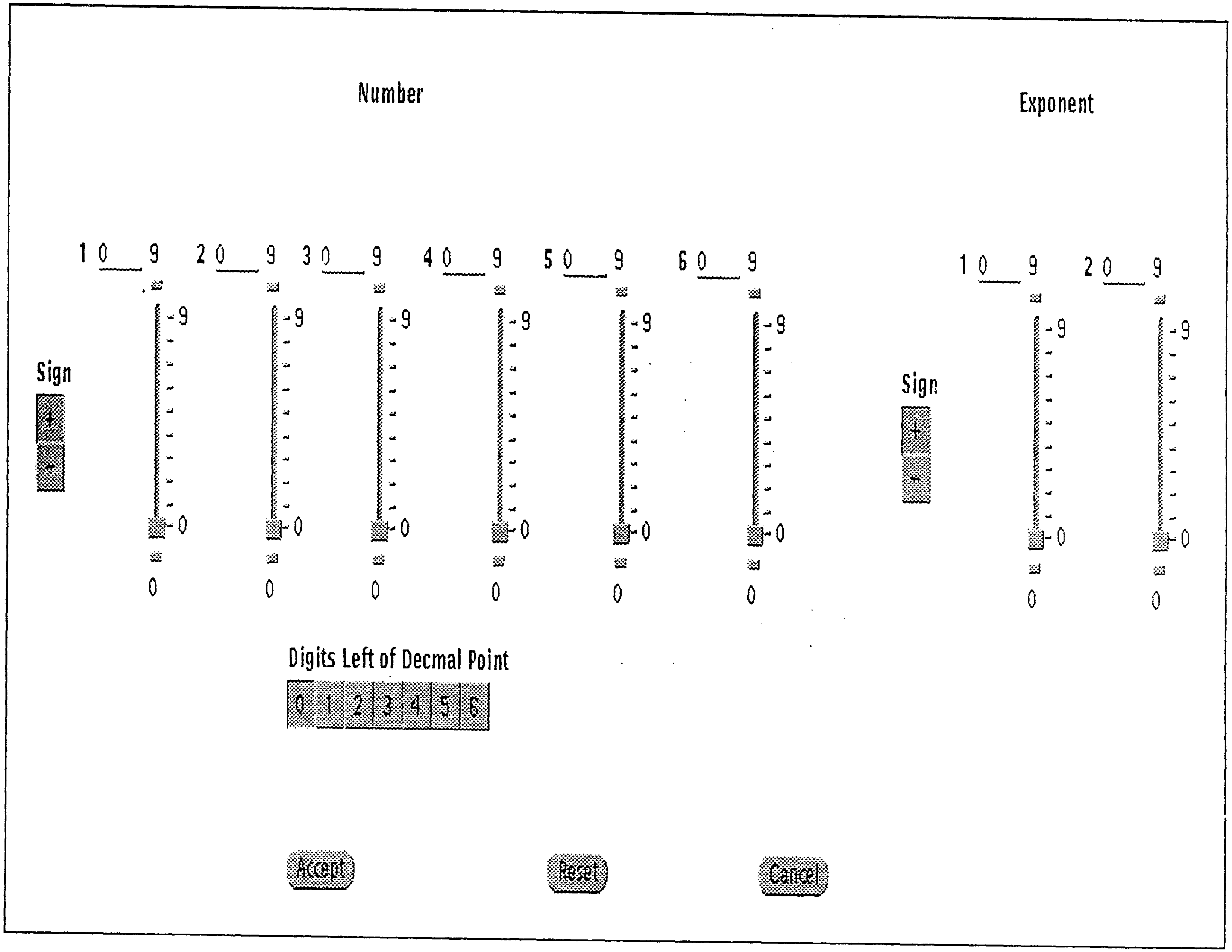

Figure 1: Floating Point Entry Popup

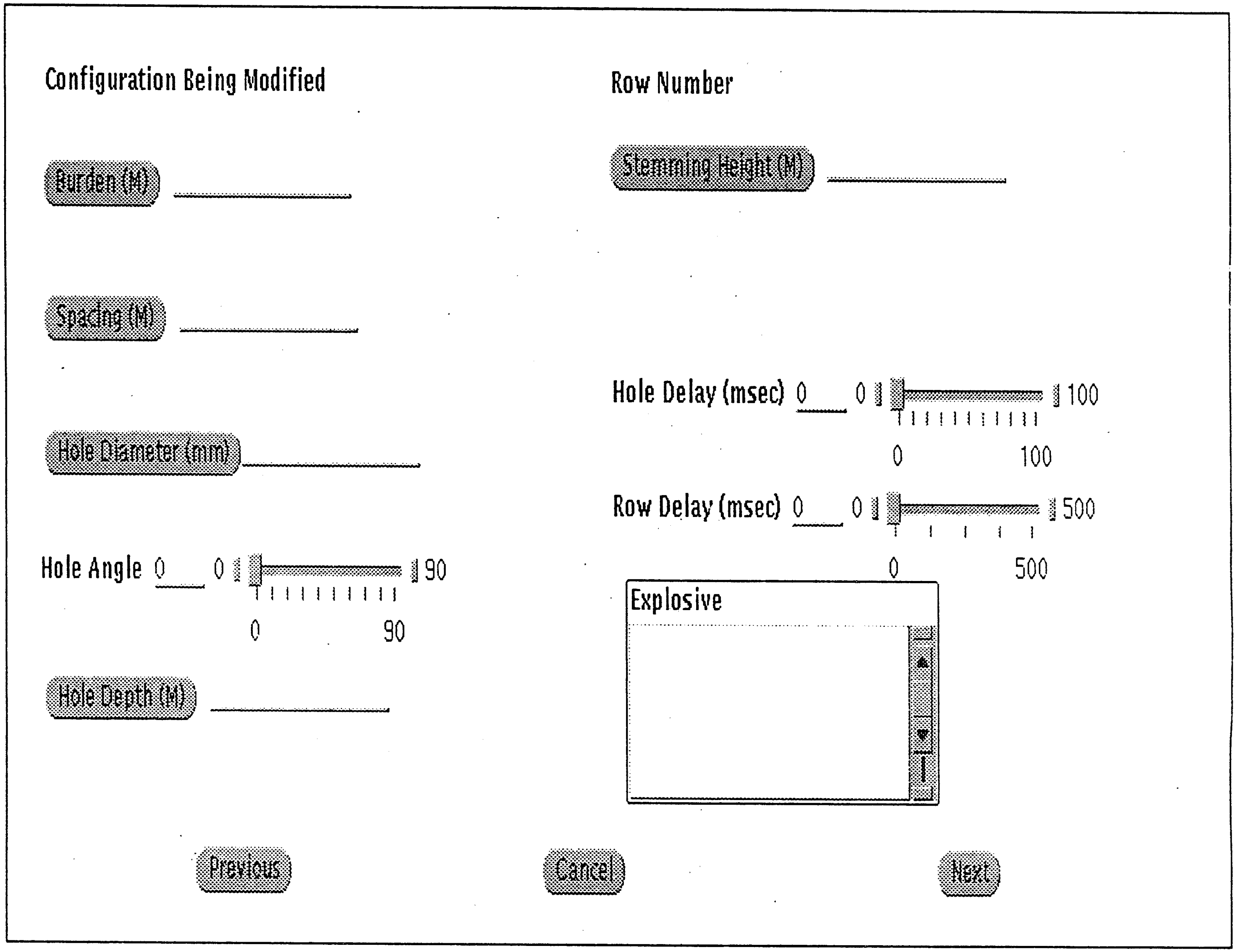

Figure 2: Row Entry Popup

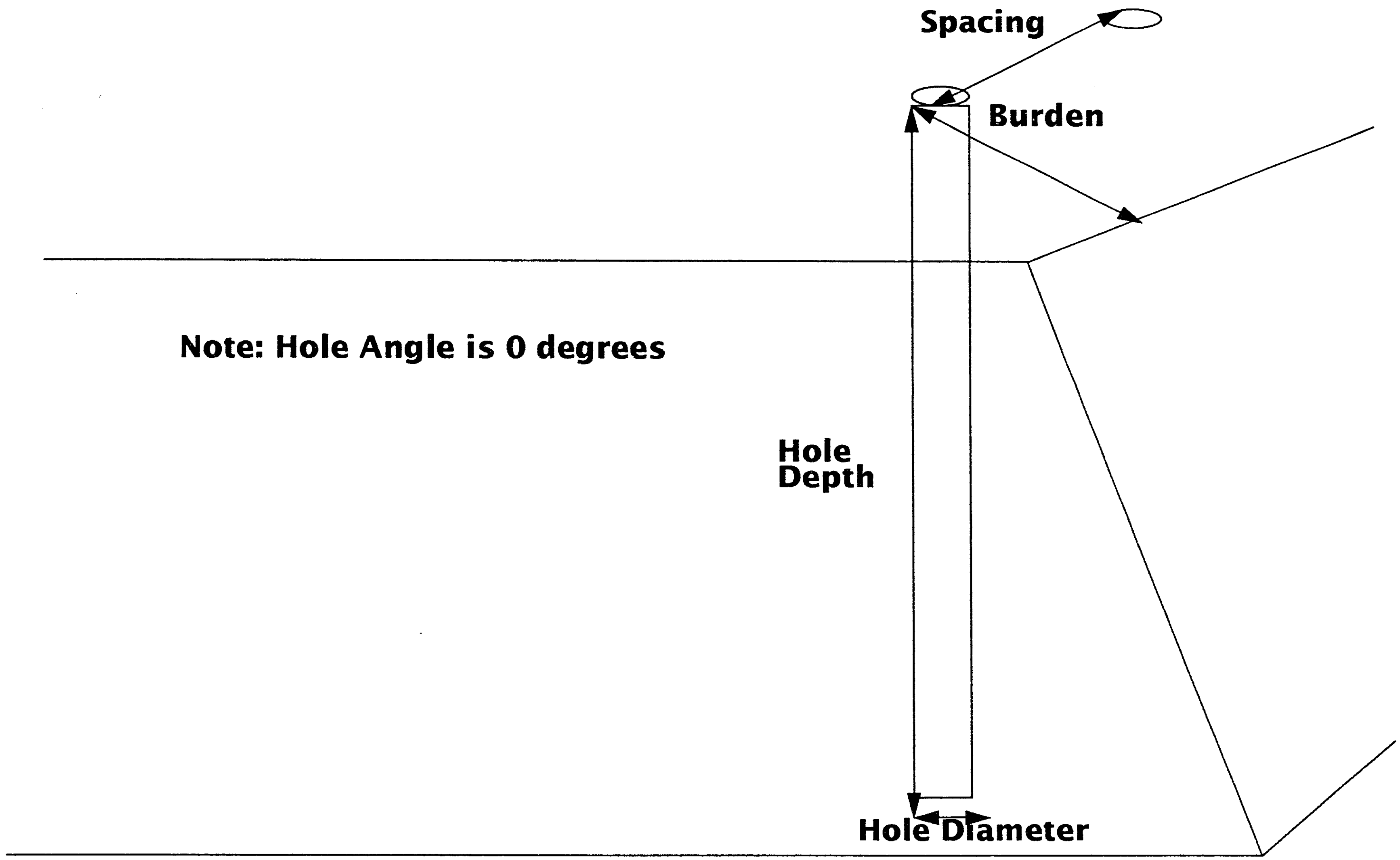

Figure 3 : Row Entry Parameters

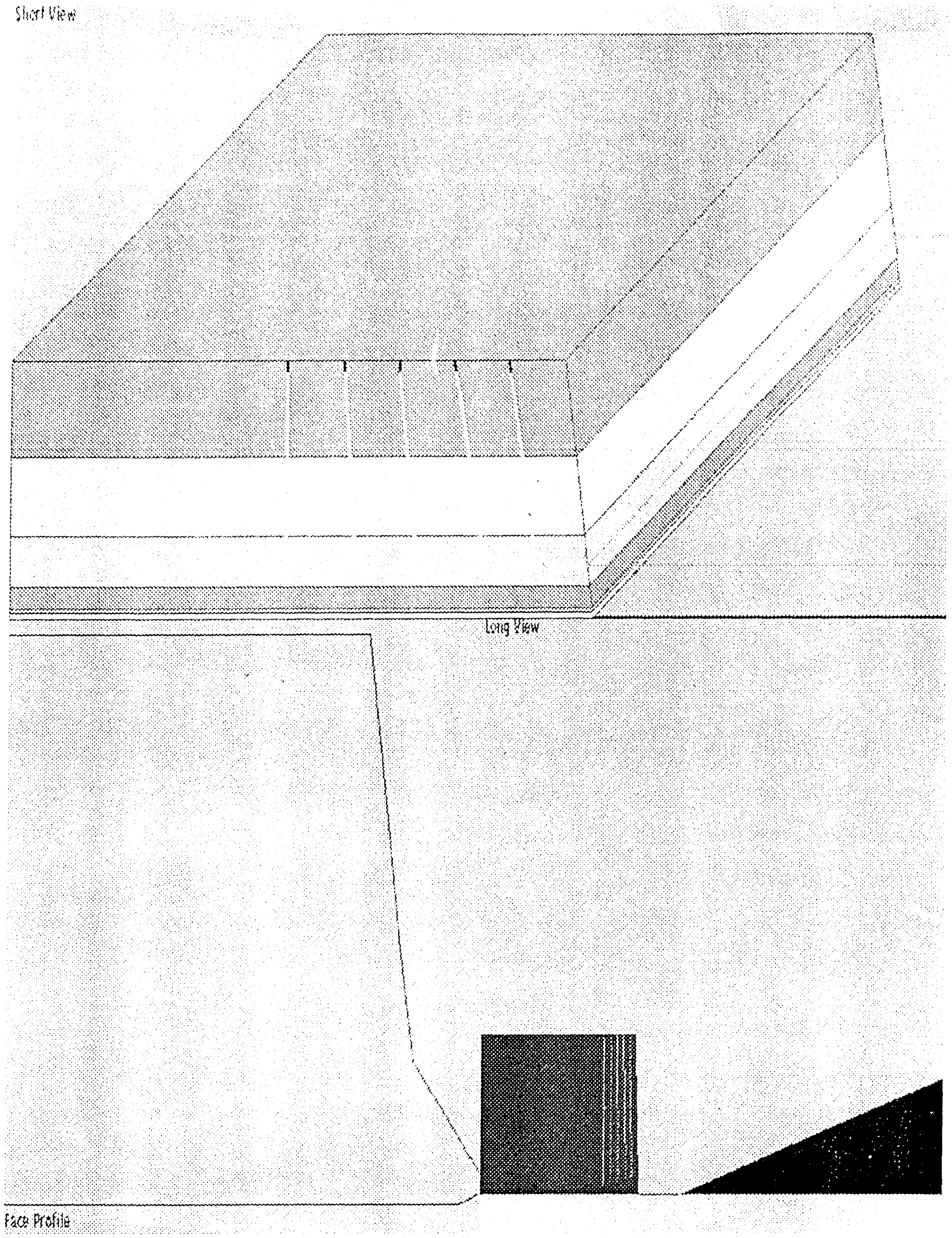

Figure 4: Row Graphics

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