the embodiments illustrated in the drawings and specific language will be used to describe the same. It will nevertheless be understood that no limitation of the scope of the invention is thereby intended, such alterations and further modifications in the illustrated device, and such further applications of the principles of the invention as illustrated therein being contemplated as would normally occur to one skilled in the art to which the invention relates.

The present invention concerns a method and apparatus for raising and lowering an array of dots according to signals received from a computer. The array can be small, for example, 48 dots arranged in 3 rows and 16 columns, for construction of braille words and sentences. In another embodiment, a larger array of dots, for example, 100 rows by 100 columns, can be used for construction of pictures, graphs, and diagrams. By way of illustration only, an array of 48 dots in 3 rows and 16 columns will be described, but those of ordinary skill in the art will recognize the scalability of the display to larger or smaller sizes, including eight pin braille cells, haptic displays for automated teller machines (ATM), clocks, paper embossers, and other devices benefitting from a haptic output. The present invention is also sutied to being packaged in six or eight pin arrays as a braille cell. Such cell can be convieniently packaged on various integrated circuit chip of standard configurations, for example on a fourteen pin 74LS138 demultiplexer.

FIGS. **1** and **2** diagrammatically depict the first embodiment of the present invention. Refreshable haptic display system **10** includes haptic display **12** which receives signals via means for transmission **13** from display controller **14**. Controller **14** receives command signals via means for transmission **15** from computer processor **16**. Processor **16** has within it software program **17**. Program **17** includes an embodiment of text, graphics, or other information in a user interface that a user would like to transmit to display **12**. By way of example only, the user interface could be the time or date when the present invention is utilized with a clock, or finanacial data when the present invention is utilized with an ATM, or other data such as queries or representation of numeric, text, or graphical data from programs such as Microsoft Word, Excel, or Power Point. Software **17** also includes the algorithms necessary to transmit the user interface as signals to controller **14** which can ultimately produce the desired responses in display **12**. By way of example only, program **17** could include ASCII characters, an algorithm for translating the ASCII characters into Braille characters, and an algorithm for transmitting the Braille characters in the proper manner to controller **14**.

Although specific elements of system **10** have been described, various substitutions and other changes would be apparent to those of ordinary skill in the art. For example, controller **14** has been shown as separate from display **12**, but could also be integrated within display **12**. Transmission means **13** and **15** are diagrammatically depicted as electrical harnesses with connectors but could also be wireless means, relying on infrared or radio frequency signals being passed between the appropriate transmitters and receivers. By way of further example, software **17** need not reside wholly within computer **16**, but could also be partitioned and contained within controller **14** or display **12**.

Display **12** includes a top plate member **22** connected by fasteners **24** to a midplate member **26** and circuit board **28**. It is preferable that plates **22** and **26** be fabricated from a lightweight, electrically insulating material that presents low resistance to sliding.

Member **22** includes a surface **22***a* and defines an array of holes **30***a* arranged in three rows and 16 columns. These holes **30***a* are further arranged in groupings **32** of two columns each. Each of the eight groupings **32** are spaced apart from each other by dimension A, which is preferably about 24 inches. Within a particular braille cell or grouping **32**, the holes are separated by dimension B which is preferably 0.095 inches. The preferred values for A and B are compatible with standard braille requirements. Other values for A and B are possible, provided that A is sufficiently larger than B so that the user will be able to haptically note one grouping **32** from another grouping **32**. Although eight groupings **32** have been depicted, it is easy to see that the display can be made larger or smaller, to provide more or less haptic information.

Slidably located within each hole **30***a* is a corresponding pin **34**. In one embodiment, pin **34** represents a portion of a Braille display **12**. At the top of each pin **34** is a pinhead **36** which is preferably rounded, beveled or chamfered. Pin **34** includes a shaft section **38** that extends through holes **30***b* within midplate member **26** and which terminate above circuit board **28**. Pins **34** are slidable within holes **30** and **30***b*. Holes **30***b* are generally aligned with and correspond to holes **30***a*. Pins **34** are preferably fabricated from a rod or tubing of material that slides easily within the materials chosen for plates **22** and **26**. The rod material should preferably be lightweight, and both electrically and thermally insulating.

Each assembly of one or more pins, shape memory spring, and heating means such as the various resistive or thermoelectric heaters, and their alternatives and equivalents described herein, comprise an actuator **35**. The pin is actuated to a different position in response to heating of the shape memory spring. Although various embodiments will be discussed in which actuator **35** is applied to provide haptic information, those of ordinary skill in the art will recognize other uses for actuator **35**.

Each pinhead **36** corresponds to a dot within a braille matrix when a pin **34** is in the **34***a* upward or first position. The user can touch head **36** with his fingers. Pinhead **36** fits within and is slidable in hole **30***a*. When pin **34** is in the **34***b* second position, pinhead **36** is depicted below the top surface of cover plate **22**. Those of ordinary skill in the art will also recognize an alternate construction that if head **36** were made slightly larger than hole **30***a*, then head **36** could also serve as a downward mechanical stop for pin **34** in the **34***b* downward position. In this alternate construction, head **36** could be separately fabricated from pin **34** and then bonded thereto. In this alternate construction head **36** would be approximately flush with the top surface of plate **22** when pin **34** is in the **34***b* downward position, and would be discernably above the top surface of plate **22** when pin **34** is in the **34***a* upward position. Thus, the user will be able to haptically discern between the **34***a* and **34***b* positions.

The motion of pins **34** is constrained in some embodiments by a downward stop **40** and an upward stop **42** attached to or integral with each shaft **38**. Downward stop **40** is located above plate **26** and prevents downward motion of shaft **38** when stop **40** is in contact with plate **26**. Upward stop **42** is located on shaft **38** beneath plate **26** and prevents upward motion of shaft **38** when stop **42** is in contact with the bottom surface of plate **26**. Stops **40** and **42** are similar to washers, and have an inner diameter approximately equal to the outer diameter of shaft **38**. Stops **40** and **42** are attached in position to shaft **38**. Alternatively, stops **40** and **42** could also be integral with shafts **38**. Other embodiments of the present invention include upward or downward stop within a support mechanism that supports pin **34** in the first position.