

from an electrical contact at the lower end of the tactile element, through the actuator, and into the outer tube of the tactile element. The actuator heats, due to electrical resistance, contracts and exerts a downward force on the pressure medium. The upper portion of the tactile element is drawn below the user contact surface, indicating the absence of information. Distributed pulse width modulation allows instantaneous power requirements to be minimized, and only low safe voltages are needed to operate the array. By applying a bias force to all actuators via a common reservoir of either pneumatic or hydraulic pressure, the design is simplified, and reliability is increased. When integrated with a computer, the refreshable tactile array of elements gives users access to full computer generated screens of text and graphical information in real time.

Becker et al., U.S. Pat. No. 6,417,821 discloses a tactual computer monitor including rows and columns of rectangular cells. Each cell includes four rows and two columns of movable pins which are felt and read by a blind person. The pins are driven by electromechanical impact drivers and are held in position by resilient elastomeric cords. The impact drivers are carried on a bi-directional print head which travels beneath the movable pins. An erasing mechanism is provided to positively drive the pins downwardly to erase the characters produced by the print head.

Gupta, U.S. Pat. No. 6,459,364 discloses a method of communicating electronic information via a display device having a matrix of movable tactile elements. The method includes displaying a representation of a file containing hypertext links on a first portion of the matrix, and displaying a list of the hypertext links on a second portion of the matrix. The representation may include graphical elements and text symbols such as Braille.

Petersen, U.S. Pat. No. 6,734,785 discloses a tactile display system that includes a housing containing a tactile pin movable axially transverse of a reference surface and an actuator mechanism engagable therewith for selective movement between raised and lowered positions. An elongated electromagnet distant from the reference surface is aligned with the tactile pin and has spaced poles of opposite, selectively reversible, polarity. A generally spherical rotatable positioning member being a permanent magnet having a peripheral surface which is partially a spherical surface and partially a truncated surface has an axis of rotation coaxial with the tactile pin and the electromagnet and is responsive to operation of the electromagnet, being movable between a first position at which the spherical surface faces the tactile pin, causing positioning of the tactile pin at the raised position and a second position at which the truncated surface faces the tactile pin causing positioning of the tactile pin at the lowered position.

Prince et al., U.S. Pat. No. 6,743,021 discloses a refreshable display system with a flexible surface, with one application being a refreshable Braille display systems for use as a monitor for computer systems.

Roberts et al., U.S. Pat. No. 6,776,619 discloses an apparatus and method for refreshable tactile display, the apparatus being preferably embodied as a rotating-wheel refreshable Braille reader. The reader includes a housing having a reading aperture with a rotatable wheel assembly maintained therein so that a display surface of a rotating wheel passes the reading aperture. The wheel has endless rows of openings defined therethrough to the display surface, a pin held in each opening and freely movable therein. Actuators, at least equal in number to the rows of openings but substantially fewer in number than the openings, are held at a static location relative to the wheel for selectively moving pins in the rows so that Braille

characters are arrayed at the display surface after passing the static location. Braille characters are thus streamed across the reading aperture of the housing.

Souluer, U.S. Pat. No. 6,827,512 discloses a refreshable display unit with a housing, a plurality of refreshable cells housed in the housing, the cells having a guide block with at least six holes, six motors each with a coupler which may be rotated by the motor, a pin fastened to each coupler and extending into engagement with one of the holes of the guide block, and a stop mounted on each coupler for engaging stop elements mounted on the housing for limiting the rotation of the coupler, the placement of the stop elements on the housing being such that it controls the height extension of the pin fastened to the coupler with respect to the guide block, the unit further having a connector for connecting the display unit to the electronic means of a computer. A unit may have a plurality of keys for inputting a character, including at least two sets of keys, a first set being used when the keyboard is oriented in a first direction and a second set being used when the keyboard is oriented in a second direction.

Goldenberg, U.S. Pat. No. 6,902,403 discloses a Braille pin that has three parts sharing a common longitudinal axis. A first part has a first breadth and includes a rounded tip felt by a user. A second part has a noncircular transverse cross-section and has a breadth greater than the first breadth. A first shoulder is formed by the juncture of the first and second parts. A third part has a third breadth less than the second breadth. A second shoulder is formed at the juncture of the second and third parts. A pinhole has first, second, and third sections that respectively receive the first, second and third parts of the pin. The first shoulder limits upward pin travel by abutting an overhang at the juncture of the first and second pinhole sections. The second shoulder limits downward pin travel by abutting a step at the juncture of the second and third pinhole sections.

Roberts et al., U.S. Pat. No. 7,009,595 discloses an apparatus and methods for an extended refreshable tactile graphic display, the apparatus including an array of pins at a display surface, with pin setting actuators and a display surface matrix preferably being separable units. The display matrix is provided by stacked functional layers having functions including temporary pin retention and pin locking.

Schleppenbach et al., U.S. Pat. No. 7,018,209 discloses various apparatus and methods for an actuator and display using one or more shape memory springs. A shape memory spring is heated and urges a pin to a first or extended position. The pin may be supported in the first position by a supporting mechanism. The shape memory spring is heated electrically, and in some embodiments under the control of a processor. The present invention may be used to display information provided in a user interface from a computer program, including text, numerical data, and graphical images.

The related art described above discloses refreshable tactile displays which can produce Braille text and graphics using tactile pins controlled by various types of actuator devices. However, the prior art fails to disclose a refreshable tactile display that uses compressible tactile pins and a module structure that is easily cleaned. The present disclosure distinguishes over the prior art providing these and other currently unknown advantages as described in the following summary.

BRIEF SUMMARY OF THE INVENTION

This disclosure teaches certain benefits in construction and use which give rise to the objectives described below.