

**APPARATUS AND METHOD UTILIZING
BI-DIRECTIONAL RELATIVE MOVEMENT FOR
REFRESHABLE TACTILE DISPLAY**

RELATED U.S. APPLICATIONS

[0001] This application is a continuation-in-part of U.S. patent application Ser. No. 09/572,048 which is pending on the date of this application and which is entitled APPARATUS AND METHOD FOR REFRESHABLE TACTILE DISPLAY filed by inventors named herein on May 16, 2000 claiming the benefit of U.S. Provisional Patent Application No. 60/134,887, filed May 19, 1999, and U.S. Provisional Patent Application No. 60/178,699, filed Jan. 28, 2000.

FIELD OF THE INVENTION

[0002] This invention relates to tactile display devices and methods, and, more particularly, relates to such devices and methods wherein a tactile display is readily reconfigurable.

BACKGROUND OF THE INVENTION

[0003] One of the potential benefits of advances in computer and related technologies is the prospect for improved accessibility to information services for the handicapped, particularly electronically stored or transmitted information. For the blind and vision impaired, work has been done on improved accessibility by special adaptations to visual displays, by voice-based systems (voice output and in some cases voice input), and by touch-based devices. Each of these approaches is particularly useful for certain applications, and serves a certain part of the population of users.

[0004] The most common implementation for a touch-based computer-driven display is the refreshable Braille reader. This is a device which produces a pattern of raised dots in the six (or eight) dot cells that represent Braille characters (see U.S. Pat. Nos. 6,109,922 and 4,551,102, for example). Often, the dots are controlled by actuators (typically one per dot in each cell), and can be individually set to change the Braille characters being displayed on each Braille cell. Typically, a single line of Braille is made available, ranging from a relatively short line for a portable device, to 80 characters or more for a device built into a desktop keyboard. These devices produce a usable, refreshable Braille display, but suffer the drawbacks of extremely high cost and mechanical unreliability (due in large part to the great number of mechanical components). Cost and reliability issues have thus hindered the expanded use of Braille as a computer interface.

[0005] Some heretofore known full-scale Braille readers may contain hundreds of actuators. Since the traditional method of constructing a refreshable Braille display producing a linear array of Braille cells requires a separate actuator for every dot of every cell in the display, an 80 cell display of 8-dot Braille (per cell) would require 640 actuators. Actuators are the primary expense in traditional Braille displays, and also represent the most likely source of introduced unreliability into the system.

[0006] Other heretofore known systems rely on complex systems of magnets (electromagnets and permanent magnets) to move and retain Braille characters. Such systems have not always been found to produce reliable results and/or are expensive to manufacture given the need for specificity and isolation of the magnetic effects from one Braille dot to the next.

[0007] Improvement in such devices producing computer-refreshable Braille text for tactile reading by the blind and visually impaired could thus be utilized thereby broadening accessibility to computer services such as electronic books, e-mail and other network access, and general computer use. Improvements in cost and mechanical reliability must be attained in order to facilitate more widespread use of refreshable Braille devices. Mechanically simplicity over existing refreshable Braille devices, while providing much of their functionality as well as additional features, would be desirable for users while greatly lowering cost and improving reliability in comparison to existing systems. Moreover, such systems should be easily reversible and searchable (forward and back) so that a user may review Braille text as necessary and desired by the user.

SUMMARY OF THE INVENTION

[0008] This invention provides apparatus and methods for producing refreshable tactile display, in particular refreshable Braille text that can be streamed at a display surface in either forward or backward order by utilizing bi-directional relative movement of components of the apparatus. The apparatus can be produced at a great reduction in cost of manufacture over heretofore known devices while yet realizing greatly increased mechanical reliability and simplicity.

[0009] The refreshable Braille reader broadly includes a display assembly having an outer surface with a plurality of openings therethrough, the openings arranged in rows. Pins are mounted in the openings and are movable therein. Actuating means maintained at a station adjacent to the surface of the display assembly selectively moves the pins in their openings by contacting the pins so that first ends of the pins are selectively raised from or not raised from the surface. At least one of the actuating means and the display assembly is movable relative to the other of the actuating means and the display assembly in either of two directions, controlled pin movement in the openings being effectable while relative movement occurs in either of the two directions.

[0010] The actuating means preferably includes at least a first actuator assembly having actuators at least equal in number to number of the rows of openings in the display assembly surface. Each the actuator includes a driver, a shaft selectively extendible and retractable by the driver and first and second contact tips at the shaft. The actuators are positioned so that the first contact tip can selectively contact the first ends of the pins and the second contact tip can selectively contact the opposite ends of the pins.

[0011] In the now preferred embodiment of the refreshable Braille reader, a cylinder connected with a motor for rotation thereof in either of two directions is utilized. The cylinder has a cylindrical outer surface a part of which defines a tactile display area and a cylindrical inner surface, the openings extending between the surfaces.

[0012] The actuators are statically positioned, are at least equal in number to the rows of openings through the cylinder, and are configured so that the pins are selectively contactable at either of their ends by different ones of the actuators during cylinder rotation in either of the two directions, thereby streaming Braille text across the display area in either forward or backward order depending upon