

vocabulary. Medicine, law, accounting, engineering, and science careers are restricted by this limitation. Voice synthesizing devices are not effective at dealing with tabular material. The voice synthesizing devices do not provide blind accountants and bookkeepers the access they require to spreadsheets and databases. Furthermore, voice synthesizers are not capable of limited document skimming, or provide a means to address accessing links otherwise known as sub-directories or complementary subject indicators. Perhaps most important, these reading devices provide limited ability to edit text or tables.

[0016] The devices currently available for the sight impaired are limited and have drawbacks in that they do not have fast enough refresh rate or sufficient Braille character ability to replicate a computer display, including memory capacity, readable area, and scanning and highlighting functions; are bulky and heavy; can not be adapted for different applications, i.e., a lap top vs. a desk top computer, cannot "display" technical, accounting, spreadsheets, or other specialized forms of display which are not a basic textual document; and are expensive to manufacture.

[0017] Accordingly, a need exists for a refreshable Braille display that overcomes the above mentioned limitations and drawbacks.

SUMMARY OF THE INVENTION

[0018] The present invention is further directed to 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.

[0019] In one embodiment, the present invention includes a refreshable Braille display system or a module in such a system comprising a) a plurality of microelectromechanical valves having a top surface and a bottom surface, each microelectromechanical valves having an opening or positioned in line with an opening each of which represents a Braille dot and each opening arranged in a pattern of Braille cells with the Braille cells forming a Braille display; and b) an elastomeric polymer having a upper and a lower surface, the lower surface of the elastomeric polymer being sealed about each opening which represent the Braille dots; wherein during operation of the display system the upper surface of the elastomeric polymer forms a plurality of Braille dots which are extended and retracted based upon the operation of the electromechanical valves.

[0020] In another embodiment, the present invention includes a refreshable Braille display system or a module in such a system comprising a) a plurality of microelectromechanical piezoelectric based devices having a top surface and a bottom surface, each microelectromechanical piezoelectric based device having an opening or positioned in line with an opening each of which represents a Braille dot and each opening arranged in a pattern of Braille cells with the Braille cells forming a Braille display; and b) an elastomeric polymer having a upper and a lower surface, the lower surface of the elastomeric polymer being sealed about the openings which represent the Braille dots; wherein during operation of the display system the upper surface of the elastomeric polymer forms a plurality of Braille dots which are extended and retracted based upon the operation of the electromechanical piezoelectric based devices.

[0021] In another embodiment, the present invention includes a refreshable Braille display system or a module in such a system comprising a) a plurality of microelectromechanical shape memory alloy based devices having a top surface and a bottom surface, each microelectromechanical shape memory alloy based device having an opening or positioned in line with an opening each of which represents a Braille dot and each opening arranged in a pattern of Braille cells with the Braille cells forming a Braille display; and b) an elastomeric polymer having a upper and a lower surface, the lower surface of the elastomeric polymer being sealed about the openings which represent the Braille dots; wherein during operation of the display system the upper surface of the elastomeric polymer forms a plurality of Braille dots which are extended and retracted based upon the operation of the electromechanical shape memory alloy based devices.

[0022] Additional features and advantages of the invention will be set forth in the detailed description which follows, and in part will be readily apparent to those skilled in the art from that description or recognized by practicing the invention as described herein, including the detailed description which follows, the claims, as well as the appended drawings.

[0023] It is to be understood that both the foregoing general description and the following detailed description are merely exemplary of the invention, and are intended to provide an overview or framework for understanding the nature and character of the invention as it is claimed. The accompanying drawings are included to provide a further understanding of the invention, and are incorporated in and constitute a part of this specification. The drawings illustrate various embodiments of the invention, and together with the description serve to explain the principles and operation of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] Further features of the present invention will become apparent to those skilled in the art to which the present invention relates from reading the following specification with reference to the accompanying drawings in which:

[0025] **FIG. 1** is a view of the present invention.

[0026] **FIG. 2** is a layout of the module showing Braille cells.

[0027] **FIG. 3** is an exploded view of a schematic for the module structure.

[0028] **FIG. 4** is a block diagram of the control function of a single module of the present invention.

[0029] **FIG. 5** is schematic representation of the Braille dots actuation scheme.

[0030] **FIG. 6** is a view of the section cut along lines 2-2 on **FIG. 2**

[0031] **FIGS. 7A**, and **7B** are detail views of a MEMS device and Braille dot extended and retracted, respectively.

[0032] **FIGS. 8A**, and **8B** are details of a MEMS valve device that indirectly actuates a Braille dot.