smooth tactile surface presenting protuberants only for the tactile pins and the cursor positioning buttons as desired. The tactile cell assemblies in combination with the bused frame and the novel tactile pin cap for multiple cells enables self-alignment of the cells, thereby eliminating the additional alignment and securing requirements of the prior art.

BRIEF DESCRIPTION OF THE DRAWINGS

For a fuller understanding of the nature and objects of the invention, reference should be made to the following description taken in connection with the accompanying drawings in which:

FIG. **1**A is a perspective view of a first side of the novel electromechanical tactile cell in accordance with the present invention.

FIG. **1**B is a perspective view of a second side of the novel electromechanical tactile cell in accordance with the present invention.

FIG. **2** is a detailed perspective view of the multiple element conductive support and conductive fulcrum pin in accordance with the present invention.

FIG. **3** is a perspective view depicting the interconnection between an electromechanical tactile cell in accordance with the present invention and a frame.

FIG. **4** is a perspective view of the electromechanical tactile cell in accordance with the present invention as incorporated into a refreshable Braille display.

FIGS. **5**A-**5**B are views of a removable negative stop assembly.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to FIGS. **1**A and **1**B there are shown perspective views of opposite sides of an electromechanical tactile cell **40** incorporating features of the present invention. While alternations are possible to the number and placement of bimorph reeds **20** without departing from the invention, FIGS. **1**A and **1**B illustrate an embodiment in which eight reeds are conductively secured to a printed circuit board **36**, four on each side. The reeds are held in place using a multiple element conductive support **32** in combination with a conductive fulcrum pin **34**. In addition to securing the piezoelectric reed to the printed circuit board, these support elements also provide electrical contact and assist with proper alignment of the reeds. To reduce manufacturing costs, the multiple element conductive support **32** and the conductive fulcrum pin are adapted for surface mount technology to be placed on the printed circuit using automated placement equipment. The piezoelectric reeds are then inserted between the support and the pin either individually or with the assistance of an alignment jig. The use of a fulcrum pin **34** provides improvements in positioning for calibration of the assembly. In this embodiment, the support **32** and the fulcrum pins **34** are positioned such that the placement of the reeds **20** results in a stairstep pattern. The conductive extension of the bimorph reed **26** are then soldered to a pad on printed circuit board completing the necessary electrical connections to operate the piezoelectric reed as an actuator. To assist in alignment of the reeds, an alignment fixture can be used to accurately control the position of the work end of the bimorph.

In the embodiment shown in FIGS. **1**A and **1**B, the piezoelectric reed **20** is a parallel polled bimorph. As such, the element includes a parallel polled bimorph having a top piezoelectric plate, a bottom piezoelectric plate, and a conductive strip positioned between the top plate **10** and the bottom plate **15** and insulated therefrom, the conductive strip **26** extending beyond the top plate **10** and the bottom plate **15** at a first end of the reed **26**. It is known that parallel polled bimorphs provide greater deflection with less power and improved efficiency. The reeds utilized herein are electrically polarized for parallel operation at the time of manufacturing by the application of a high voltage conductive layers. In an exemplary embodiment, a source of relatively high voltage, as of +200V is applied to the multiple element conductive support **32**, which is connected to the top plate **10** of the bimorph the bottom plate **15** is connected to the ground, through the conductive fulcrum pin **34**. The voltage level at the central conductor **26** is then switched between the high positive ground potential and the ground potential, which places the full 200V across the lower piezoelectric layer, or across the upper piezoelectric layer, as determined by the state of the central conductor. When the positive potential is presented across the upper piezoelectric plate, the reed is deflected upward and conversely when the positive potential is applied across the lower piezoelectric layer the reed is deflected downward. In the case of a Braille or graphic tactile display the deflection of the reed moves a corresponding tactile pin up or down to provide the pattern of a Braille character to a user. With the bimorph operated in this manner, the operating voltages are applied in the direction in which the layers were permanently polarized. Accordingly, depolarization of the reeds with continued usage does not occur.

As depicted in the detail of FIG. **2**, the plurality of multiple element conductive supports **32** secured to the printed circuit board **36** further include a conductive base **37**, and a plurality of conductive flexion members **33** integral to the conductive base **37**. A variety of designs of the multiple element conductive support are effective in meeting the requirements of providing support and an electrical connection to one side of the bimorph reed. In a preferred embodiment, the plurality of conductive flexion members **33** further comprises an arm including a substantially convex portion, the convex portion being biased in a direction to contact the piezoelectric element reed. The flexion members **33** may be positioned in a stepped pattern relative to the conductive base **37**. Accordingly, the piezoelectric element reeds **20** are positioned between the flexion member **33** and the conductive fulcrum pin **34** to secure them to the printed circuit board **36** and provide the required electrical connections. With this embodiment, the flexion member **33** is in contact with a first electrical contact surface coincident with the top plate and the conductive fulcrum pin is in contact with a second electrical contact surface coincident with the bottom plate of the bimorph. Alternatively, the flexion member may contact the bottom plate and the conductive fulcrum pin may contact the top plate of the bimorph. The distance between the convex portion of the flexion member **33** and the fulcrum pin **34** is slightly less than the thickness of a bimorph reed **20**. Each flexion member **33** is formed of an electrically conductive flexible and resilient material so that a bimorph reed **20** disposed in sandwiched relation there between is firmly engaged thereby.

Referring now to FIG. **3**, the electromechanical tactile cell **40** in accordance with the present invention is illustrated as positioned in a frame or housing **44**. A plurality of receiving socks **42** are positioned on the frame **44** in spaced relation to one another as depicted. With this configuration, a large number of tactile cells **40** can be mounted with the frame **44**. A connector positioned on each of the tactile cells **40** can be mounted within the frame **44**. A connector positioned on each of the tactile cells secures the tactile cell **40** to the frame **44** at