FIG. **4**B shows a cross-sectional view of the music-player keypad depicted in FIG. **4**A.

FIG. **5** shows the array shown in FIG. **2**A communicatively coupled with a keyboard emulator controller having a selector to select one of several keyboards for emulation by the array of microchambers.

FIG. **6**A shows the array of microchambers configured as a selector to select one of several keyboards for emulation by the array of microchambers.

FIG. **6**B shows the array of microchambers shown in FIG. **6**A configured as the selected keyboard.

FIG. **7** shows an exemplary embodiment of a microchamber controller that is a part of a keyboard emulator controller of a reconfigurable keyboard.

FIG. **8**A shows a second exemplary system that incorporates a sensory feedback array for implementing the reconfigurable keyboard shown in FIG. **1**.

FIG. **8**B shows the array shown in FIG. **8**A configured, in a first exemplary embodiment, as a telephone keypad.

FIG. **8**C shows a cross-sectional view of the telephone keypad depicted in FIG. **8**B.

FIG. **9** is a flowchart of one exemplary method of keyboard emulation using a reconfigurable keyboard.

DETAILED DESCRIPTION

The various embodiments generally describe systems and methods related to a reconfigurable interface that emulates a user-specified keyboard by generating hard keys associated with the user-specified keyboard. Furthermore, in one exemplary embodiment, the hard keys provide tactile feedback to the user of the reconfigurable interface.

FIG. **1** shows an exemplary embodiment of a device **100** having a reconfigurable interface **120**. Interface **120** includes a reconfigurable keyboard **110** containing a keyboard emulator controller **115**. Reconfigurable keyboard **110** is communicatively coupled to a display **105** that provides a video display of images, text, and/or data, in response to user input through keyboard **110**. Device **100** shown in FIG. **1** represents, in general, a hand-held device or any other device having one or more hard keys operable by the user. A few examples of such devices are: a personal digital assistant (PDA), a cellular phone, a desktop personal computer (PC), a laptop, and a hand-held remote control.

It will be understood that, where used, the term "keyboard" is intended for purposes of explanation only, and, consequently, the term encompasses various interfaces such as the keypad of a PDA, the keypad of a cellular phone, the data-entry tablet of a computer, and the control panel of a media player such as an MP3 player. Also, in the exemplary embodiment illustrated in FIG. **1**, device **100** is shown to include a display **105**. In an alternative embodiment, display **105** may be omitted, and in yet another alternative embodiment, keyboard emulator controller **115** may be located external to keyboard **110**.

FIG. **2**A illustrates an array **200** of microchambers used in a first exemplary embodiment of reconfigurable keyboard **110**. In the context of this exemplary embodiment, a microchamber may be broadly described as an enclosure having a height that can be controllably varied to generate upon reconfigurable keyboard **110** an emulated hard key that emulates a key of a user-selected keyboard.

A first group of adjacent microchambers collectively provides one keypad surface equivalent to one hard key. Several such groups of adjacent microchambers may be used to emulate several hard keys. For example, if the ESC key of a QWERTY keyboard has a 2 cm^2 keypad surface area and each microchamber provides a 0.5 cm^2 keypad surface area, four such adjacent microchambers collectively provide the keypad surface area corresponding to the ESC key.

Turning to array **200**, the individual dimensions, as well as the number of microchambers contained in array **200**, are generally defined by the dimensions of the reconfigurable keyboard **110**. Consequently, in an embodiment of reconfigurable keyboard **110** sized as a PDA keypad in which a key occupies a 24 mm^2 keypad surface area, each microchamber is configured in a first embodiment, to provide a 1 mm^2 keypad surface area, thereby allowing **24** adjacent microchambers to collectively provide the keypad surface area corresponding to one PDA key. In a second embodiment, each microchamber may be configured to provide a 4 mm^2 keypad surface area, thereby allowing 6 adjacent microchambers to collectively provide the keypad surface area corresponding to one PDA key.

Each microchamber of array **200** is generally configured to have two different heights—a first height corresponding to an unused surface of a keyboard and a second height corresponding to an emulated hard key. Three adjacent microchambers **205**, **210**, and **215** of array **200** are shown in FIGS. **2**A, **2**B, **2**C, and **2**D and are used below to describe the configuration of an emulated hard key.

In a first embodiment, FIG. **2**C shows a cross-sectional view of the three microchambers, with microchambers **205** and **215** each configured to have a first height, and microchamber **210** configured to have a second height that is greater than the first height. In this first embodiment, microchamber **210** constitutes one of a group of microchambers that collectively constitute a raised emulated hard key, while microchambers **205** and **215** constitute two of a group of microchambers that collectively constitute an inactive surface of the reconfigurable keyboard. The inactive surface of the reconfigurable keyboard corresponds to the inactive surface of a conventional keyboard, for example, the peripheral surface around hard keys of the keyboard.

In a second embodiment, FIG. **2**D shows a cross-sectional view of the three microchambers, with microchambers **205** and **215** each configured to have a first height, and microchamber **210** configured to have a second height that is less than the first height. In this second embodiment, microchamber **210** constitutes one of a group of microchambers that collectively constitute a recessed emulated hard key, while microchambers **205** and **215** constitute two of a group of microchambers that collectively constitute an inactive surface of the reconfigurable keyboard.

Various combinations of the above-described features will be used in various embodiments. For example, various groups of microchambers can be configured to be in one of three, rather than two, alternative positions: up (convex), flat, and down (concave). The up position denotes a raised emulated hard key, the down position a recessed emulated hard key, and the flat position the inactive surface of the reconfigurable keyboard. In a first embodiment, both the raised and recessed emulated hard keys are used for hard key functions, while in a second embodiment, the recessed emulated hard keys provide a place-holder functionality that makes it easier for the user's fingertips to locate functional raised emulated hard keys.

Several alternative systems and methods can be employed to implement the emulated hard keys using the microchambers shown in FIGS. **2**A, **2**B, **2**C, and **2**D. In a first exemplary embodiment, microchambers **205**, **210**, and **215** have ports **221**, **222**, and **223** respectively located at their bases. The ports are connected to a manifold **244** that carries air to the microchambers. Air is injected or removed from