

electric current is run through the shape memory alloy, its length shortens by, for example, approximately 5% or any other length depending upon the type of shape memory alloy, and causes the pivoting elements to rise up and push against the flexible skin structure causing the appearance of a bump. When the electrical current is no longer applied, the flexible skin structure and underlying pivoting element returns to the neutral position due to tension in the flexible skin.

[0048] In another embodiment shown in FIG. 10*b*, a second series of pivoting elements 1002, as part of a hinge lock structure, may be introduced beneath the first series of pivotal elements 806, 808 to act as locks. When the first series of hinged elements 806, 808 are actuated, the second series of pivoting elements 1002 are positioned so as to fall in to gaps 1000 created by the motion of the first set of pivoting elements thereby locking them into the raised position or to simply position underneath the first pivotal elements. It will be recognized that any other location may also be used or that any other suitable technique may be employed. When the electric current applied to the corresponding shape memory alloy element 812 that moves the first set of hinged elements 808 is stopped, the locking action of the second set of elements 1002 holds the first pivoting elements 806, 808 in place by a biasing element 1006 pulling the elements 1002 under the elements 808. By applying an electric current to a shape memory alloy element 1004 connected to the second set of pivoting elements 1002, the first set of pivoting elements 806, 808 will be unlocked and thereby allows the first series of pivoting elements to return to a neutral position due to tension in the flexible skin. This provides a type of bi-stable shape memory alloy actuation scheme. As shown, an end of a biasing element 1006 such as a spring is fixedly attached to a portion of the housing or any other suitable structure and another end is caused to contact a portion of the pivotal second set of elements 1002. The pivotal second set of elements may be made of any suitable structure such as plastic that suitably bends about a pivot point shown as 1008. As shown, a portion of the pivoting elements 1002 are also fixedly attached to a structure of the device to prevent movement of an end thereof. Similarly, the shape memory alloy element 1004 associated with each locking element 1002 also has a portion connected to the element 1002 as well as a fixed structure. The locking element swings as shown, in this example in plane of the FIG. 10*b*, for example, to block the hinged element 808 from lowering down into the plane of the page as shown. As such, the locking feature moves in the plane of the surface to lock the hinged elements. This as opposed to, for example, moving out of the plane in an opposite direction of the hinged element, which may also be done if desired. The thickness of the overall implementation, however, may be less if the locking element is caused to move in plane to the figure as shown. In this example, the hinged elements 808 rise out of the plane when actuated by an SMA element or actuator (not shown) and is blocked by the locking element moving in plane of the figure as shown. It will be recognized that although a single locking element 1002 is shown, that a suitable array of locking elements may be positioned for any respective pivoting hinged element 808. In addition, it will be recognized that in this example, a configuration as shown that provides a passive lock and an active unlock condition. However, it will be recognized that by reversing the bias element and the shape memory alloy element 1006 and 1004 respectively, that an active lock and a passive unlock structure may be employed. Hence, one or more pivoting elements serves as a type of pivot

lock structure made of a shape memory alloy, the same type for example, as noted above. The pivot lock structure is coupled to the control logic 200 and is controlled to be positioned to lock the pivoting elements in a desired position. The pivot lock structure may be alternately positioned to passively lock the pivoting elements in a desired position, and then controlled to release them when desired. As such the control logic controls the second shape memory alloy to deactivate the hinge lock structure to unlock the plurality of hinged elements in response to a passive actuation of the hinge lock structure.

[0049] A method for actuating a controllable skin texture surface includes, for example, controlling the first shape memory alloy to actuate the plurality of pivoting elements. In response to the actuation, the pivot lock structure will naturally act to lock the plurality of pivoting elements in a first position. The method includes deactivating the first shape memory alloy in response to the pivot lock structure being actuated. This allows the current to the first pivoting element to be removed and it is locked in place. The method may also include then unlocking the hinged elements by, for example, by actuating the first shape memory alloy and then controlling the second shape memory alloy to unlock the hinge lock structure by applying current to the shape memory alloy actuator that moves the lock structure to unlock the pivoting elements from their raised position.

[0050] FIG. 11 illustrates a portion of a portable electronic device that employs an embodiment of a controllable skin texture surface, and in this example, the portion of the electronic device is shown to be a keypad. In this example, the controllable skin texture surface includes a skin texture surface actuation structure that includes a hydraulic actuation structure that causes a change in tactile configuration of a flexible skin structure in response to movement of fluid underneath the flexible skin structure. FIGS. 12 and 13 are cross sectional views of a portion of FIG. 11 and will be described together with FIG. 11. A flexible skin structure 1100 similar to that described above with respect, for example, to FIG. 3 and elsewhere, includes fluid chambers or pockets 1102 corresponding to desired texture features that are molded into a reverse surface of the flexible skin structure. As also shown above, the wall thickness of the pockets may be thinner than other portions of the flexible skin texture to allow less resistance to fluid expansion. The flexible skin structure 1100 is bonded, for example, to a surface of the housing of the portable electronic device to form suitable seals around the various fluid chambers 1102. A supporting substrate 1104 which may be the housing of the device or a separate substrate within the device, includes fluid channels 1106 formed therein that are positioned to be in fluid communication with the fluid chambers 1102. It will be recognized that any suitable structure of first channels 1106 may be used including separate channels that allow the activation of any suitable texture location, depending upon the desired application.

[0051] As shown in FIGS. 12 and 13 for example, when fluid is removed from the channels 1106, the flexible skin structure 1100 is flat or in an unactuated state, and when an appropriate amount of fluid is moved into the various chambers, the flexible skin structure is actuated at appropriate locations to provide a three dimensional pattern on an outer surface of the portable electronic device. As shown, the channels 1106 are fluidly connected with one or more manifolds 1108 that may be molded into a surface of the housing or substrate 1104 or be a separate structure if desired. Separate