

[0021] It is still another object of this invention to provide a refreshable scanning tactile graphic display apparatus for localized sensory stimulation including a high density array of stimulus points each capable of delivering different pressure variable stimulus at a selected body location of a user, means for applying activation energy from an energy source to the stimulus points, a modulator for selective activation including pressure variation of the stimulus points utilizing the means for applying activation energy, and a control unit for controlling modulator operation.

[0022] It is yet another object of this invention to provide a refreshable scanning tactile graphic display apparatus for localized sensory stimulation to tactily simulate a virtual display that includes a plurality of fluid actuated pressure variable stimulus points held at a matrix for stimulating a localized area of a user's body, an actuator array operatively associated with the stimulus points for selected application of working fluid thereto to both actuate and modulate body applied pressure at the stimulus points, a working fluid pressurization, containment and delivery system associated with the actuator array, a control unit for controlling function of the actuator array, and a position sensing and feedback unit connected with the control unit to inform the control unit which portion of the virtual display should be tactily simulated at the stimulus points.

[0023] It is yet another object of this invention to provide a method for localized sensory stimulation to tactily simulate a virtual display including the steps of providing for delivery of stimulus at a high density set of points at a selected body location of a user, modulating the stimulus delivery at different points for selective actuation including applying variable differential pressure stimulus at the points, and controlling the modulation responsive to selected input to control which portion of the virtual display should be tactily simulated at the points.

[0024] With these and other objects in view, which will become apparent to one skilled in the art as the description proceeds, this invention resides in the novel construction, combination, and arrangement of parts and method substantially as hereinafter described, and more particularly defined by the appended claims, it being understood that changes in the precise embodiment of the herein disclosed invention are meant to be included as come within the scope of the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025] The accompanying drawings illustrate a complete embodiment of the invention according to the best mode so far devised for the practical application of the principles thereof, and in which:

[0026] FIG. 1 is a diagrammatic illustration of a 20x20 tactile array for fingertip application (about 1 centimeter on a side);

[0027] FIG. 2 is an illustration of a fingertip tactile array in accord with FIG. 1 mounted with a mouse-type tracking device;

[0028] FIG. 3 is an illustration of fingertip tactile arrays in accord with FIG. 1 mounted with a data glove;

[0029] FIG. 4 is a schematic illustration of an implementation of a small area scanning tactile display (showing only a single one of the rows of stimulus points) in accord with this invention;

[0030] FIG. 5 another schematic illustration of the implementation of a small area scanning tactile display of FIG. 4;

[0031] FIG. 6 is a sectional illustration of a first embodiment of a single stimulus point in accord with this invention;

[0032] FIG. 7 is a sectional illustration of a second embodiment of deployment of stimulus points in accord with this invention;

[0033] FIG. 8 is a schematic illustration of a rotational scanning device for actuation of a plurality of stimulus points in accord with this invention;

[0034] FIG. 9 is a schematic illustration of a fingertip tactile array with mechanical row selection;

[0035] FIG. 10 is a schematic side view illustration of mechanical row select valves as illustrated in FIG. 9 with the row selected; and

[0036] FIG. 11 is a schematic side view illustration of the mechanical row select valves as illustrated in FIG. 10 with the row deselected.

DESCRIPTION OF THE INVENTION

[0037] An array of stimulus points that covers only the surface of a localized area of the body (such as a fingertip, for example) for selectively stimulating the area will be described. The individual stimulus points do not move laterally with respect to the skin at the area, and any given stimulus point always stimulates approximately the same spot on the skin. A pattern is impressed on these stimulus points (for example, if the stimulus points in the array that make up a particular pattern are activated), and the pattern is caused to move across the surface of the skin in a uniform manner by the selective activation and deactivation of particular stimulus points in the array. This stimulation of the sensors in the skin at the selected set of points at the user's body contacted by the stimulus points is comparable to a real patterned surface moving laterally across the skin's surface thereby creating the mental impression for the user of a real patterned surface moving across the skin, even though there is no real motion of the display components across the skin.

[0038] While, for purposes of the following disclosure, the display of this invention will sometimes be referred to as a "fingertip display", it should be understood that the invention could be applied to other areas of the body for localized sensory stimulation thereat (for example, for accessibility applications, the palms of the hands, soles of the feet or the upper surface of the tongue might be used).

[0039] The required resolution of stimulus points is much higher for the localized display disclosed herein than would be the case for an extended tactile graphic display (since an extended display need only create recognizable shapes that are scanned by the motion of the fingers, while the localized display herein must "trick" the senses by creating the impression of a continuous motion). The minimum density of stimulus points needed is currently felt to be within a factor of two of the density of sensors in the skin. Tactile stimulator array 15 as illustrated in FIG. 1 and deployed as set forth hereinbelow is of sufficiently high density. An array of stimulus points 17 (movable pressure responsive pins in this embodiment) is positioned in a mounting matrix 19,