tially equal to the extension of the actuator **52** amplified by the ratio of the length of the rods over the pitch of the array, while adjacent gaps **58**A and **58**B decrease by half of this amount respectively. In this example, the average displacement of the tips is zero, but the gap distances **58**,**58**A,**58**B can be controlled locally.

As a further example, FIG. **3**D shows an activation pattern where all the tips are moved in the same direction to the left. This is achieved by shortening the left-most actuator **52**C, extending the right-most actuator **52**D, and scheduling all the other actuators in between so as to create an incline in the heights of these actuators.

FIG. **3**E shows an alternate embodiment of the invention similar to the device depicted in FIG. **3**A. A single part **60** is featured to provide for the skin contactors **50** at the top and for bonded connection to the actuators **52** at the bottom. Operation is made possible by flexural crosslinks **61**.

In FIG. **4**A, a top view is shown of a two dimensional, surface array of actuators **70** and rods **71** to form a surface display. These elements **70**,**71** are bonded to each other and are distributed so as to be spatially out of phase by half a spatial period in each horizontal directions. A similar multiplexed activation technique as for FIG. **3**A can be used to economically activate the large plurality of actuators **70** of FIG. **4**A. The actuators **70** are bonded to pads **72** supported by printed circuit board **73** as further shown on FIG. **5**A.

FIG. **4**B shows an alternate embodiment of the disclosed transducer with its rods **71** and actuators **70** of a hexagonal cross-section shape organized according to a triangular grid. The actuators **75**, shown as being prismoidal, are similarly held by a printed circuit board **76**. This configuration may have certain advantages as it permits the actuators to be more closely packed than in a square grid. Yet other embodiments not shown in a figure may employ non-uniform grids. This is particularly useful to create areas in a transducer which have more resolution than others in an effort to reduce the total number of actuators.

The arrangement shown in FIG. **5**A depicts an array of sixteen actuators **70** bonded to twenty-four rods **71** to create sixteen controllable gaps **78**. Two dimensional compression/stretch patterns may be created at the tip-ends **75** by correspondingly activating each actuator **70** under computer control.

FIG. **5**B shows an alternate realization of the device of FIG. **5**A using a flexible membrane **76** having stumps **77** on which tubular shafts **74** are inserted. Added membrane flexibility is provided by holes **79** which serve as relief to enable actuators **70** to more freely deform it locally.

FIG. **5**C shows more clearly the geometry of the membrane **76** with a top view. The stumps **77**, holes **79**, and actuators **70** form a repeating pattern.

FIG. **5**D shows the entire assembly housed in a mechanically and electrically protective enclosure **80**. The object-contacting rod ends **75** are prevented from moving beyond an amount which could threaten their structural integrity by being passed through movement-limiting holes **82**. Similarly, the space left vacant in the gap within each hole **82** may be partially filled with an elastomeric material, as depicted in FIGS. **2**B or **3**B, which permits the movement of the rods **71** but prevents foreign elements from entering the enclosure **80**. In an alternate embodiment, the rod ends **75** may be flush with the upper surface of the protective enclosure **80** so that it does not present asperities. The device so constructed would be similarly effective in causing tactile sensations.

FIG. **5**E shown an alternate embodiment of device **5**A whereby a two dimensional contactor array **90** is formed out of a single piece of material having multiple legs **91** bonded on top of the actuators **70**, which in turn are bonded to pads **72** of printed circuit board **73**. The contactor upper surfaces **75** have the same geometric relationships with respect to the actuator **70**, as upper surfaces **75** of the rods **50** of FIG. **5**A have with respect to the similar actuators **52**. Such a single-piece contactor array **90** can be conveniently manufactured of molded material. A convenient aspect ratio between its height and its pitch ranges from 5 to 10. A top view of the single piece contactor array **90** is shown on FIG. **5**F wherein sloping surfaces **91** and **92** are represented in projection as well as upper skin contacting surfaces **75**. The actuators **70**, shown also in one sample dotted outline, are bonded to lower surfaces of the legs **91** centered at the intersections **93**.

FIG. **5**G shows an application of the invention as a tactually responsive sensor. Pressure sensors **95** sandwiched between the contactor array **90** and the printed circuit board **73** are shown on FIG. **5**G with a much lower form factor than the corresponding actuators **70**. This is because there are many techniques for fabricating integrated pressure sensors **95** that are compact in height, including but not limited to force sensitive resistors (FSR), polymeric piezoelectric film, for example, one made of Polyvinylidene Fluoride (PVFC), and other techniques.

In FIGS. **5**H and **5**I another embodiment of the invention is described which addresses the need to diminish the fabrication cost and complexity in such devices. In FIG. **5**H a two dimensional surface display or sensing device is shown using a set of actuators or sensors **96** which have been partially split in the middle thereby having the configuration of a tall arch. Four of such actuators/sensors share common bonding pads **97** at the bottom, in the repeating portion of the array, with three pads **97** being shared at the edges and two at the corners. FIG. **5**I clarifies the geometrical relationships between the actuators/sensors **96** and the pads **97**.

When a voltage difference is applied to two neighbouring pads **97** one leg of a straddling actuator **96** will stretch and the other will contract. As a tactile display, the operation of the embodiment of FIG. **5**H is identical in principle to that of FIG. **5**A, yet, it uses much fewer parts in exchange for more specialized actuators. This embodiment is also suited to the complementary application of serving as a tactile sensor.

Most actuating techniques are reversible since they are based on transducing phenomena. For example, electromagnetic transducers create torque when current is driven through them but create voltage in response to velocity; shape memory alloys change their stress-strain properties when their temperature is changed but their resistance is changed when the material is strained; and piezoelectric materials change their stress-strain properties when an electric field is applied, but create electric charges when they are strained. This principle applies to the disclosed device.

The same devices as described above can, for the most part, be made to respond to some degree to mechanical signals applied to their exposed contacting field, acting as tactually-responsive sensors. Because of their construction, such devices can in many cases respond to an applied pressure field in respect of both its normal and tangential components. External processing can then be used to extract features of the pressure field. This makes the devices of the invention particularly suited for use as dual-function transducers, e.g. as sensors and as stimulators, in hand controllers.

Applications of this ability are multiple. Employed in the field of automation, the device can be used as a tactile