variety of devices may be employed as motive sources, including piezo-electric actuators, magnetostrictive actuators, electrostatic actuators, electroactive contractile or electrostriction polymers actuators (e.g. in electron irradiated P(VDF-TrFE) copolymers), heat expansion actuators, variable magnetic reluctance actuators, Lorentz effect actuators, fluid based actuators using cylinders or bladders, and other equivalently acting actuators. Recent developments in thin-film (sol-gel) piezo-electric devices which allow low voltage operation at, e.g. 5–20 volts, are particularly suited for use with the invention. The actuators may provide displacements in any direction so long as these are converted to lateral motion at the contacting tips of the skin contactors.

Many of the same elements will also serve as sensors.

The invention is equally effective at providing for tactile sensing arrays since most actuators can operates as a two way transducer and can be applied as part of a tactile sensing array. By insertion of appropriate filters between the sensing array and the display array selected features of the tactile signal may be enhanced: a tactile microscope so-to-speak.

Thus, the invention in one aspect provides a tactile transducer comprising at least one pair of adjacent contactors, each contactor having a contacting tip separated by a gap from the adjacent contacting tip, said contactor pair being coupled to transducer means to effect or sense relative displacement of said contactors and associated variation of the lateral gap distance between said contacting tips.

The transducer may be in the form of a linear array of transducers wherein multiple transducers define a sequence of gap distances between consecutive contactor tips, said contactor pairs being coupled to a multiple number of transducer means to effect or sense the variations in the inter-tip gap distances in said sequence of gap distances.

Optionally, adjacent contactors are coupled to individual, shared transducer means.

The invention may also be in the form of a transducer interspersed sets of linear transducer arrays defining an area array which includes gap areas, each gap area being surrounded by contactor tips, said contactors being coupled to said transducer means to effect or sense variations of gap areas.

A particular area array incorporates three interspersed sets of linear transducer arrays defining an array of gap areas surrounded by triplets of contactor tips carried by respective contactors, each triplet of contactors being coupled to transducer means to effect or sense variations of gap areas.

Advantageously, contactors may be mounted to associated transducer means so as to mechanically amplify the effect of the lateral displacement of the contactor tips on the transducer means. Further the gap, the gap distances, or the gap areas between contactor tips may be occupied by flexible, resilient, elastic material.

Preferrably, the transducer means operate on the basis of a piezo-electric effect.

The invention also provides a method of creating a tactile display across a plurality of contactors, each contactor having respective contactor tips separated by gaps that are actuable by actuation means, comprising operation of the actuation means to cause the contactor to be laterally displaced in relation to one another, placing a sensate object against said contactor tips to create tactile sensations. such tactile sensations being caused by varying gap distance or the gap distances, or the gap areas between the contactor tips.

In this method as in claim **9** wherein the contactor tips may be actuable by shared actuation means. Further, the gaps may be varied in size as a result of amplified transverse movements of the contactor tips in response to longitudinal movement of the actuation means.

The foregoing summarizes the principal features of the invention and some of its optional aspects. The invention may be further understood by the description of the preferred embodiments, in conjunction with the drawings, which now follow.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a pictorial representation of tactile stimulation created by lateral displacement of the teeth on a comb.

FIG. **2**A is a schematic face view of a finger being tactically stimulated by a basic, paired-contactor tactile transducer, according to the invention.

FIG. **2**B is a side view of the transducer of FIG. **2**A contained within a cross-sectioned, enveloping, outer covering.

FIG. **2**C is an alternate embodiment of a basic tactile transducer employing two bi-morph piezo-electric actuators.

FIG. **2**D is a side view of the transducer of FIG. **2**C with a spring loading feature within a cross-sectioned enveloping outer covering.

FIG. **2**E is a side view of the transducer of FIG. **2**D associated with a data input depressible platform.

FIG. **2**EE is a detail of a variant of FIG. **2**E with the transducer flexibly mounted to the platform.

FIG. **2**F is pictorial, exterior representational view of the combined input-display device of FIG. **2**D.

FIG. **3**A is a schematic side view of an electro-mechanical transducer incorporating a multiple, linear contactor array and multiple piezo-electric actuators.

FIG. **3**B is a detail side view of the contactors of FIG. **3**A incorporating motion-limiting damping and protective elastic blocks.

FIG. **3**C depicts the effect of the action of one actuator on the position of neighbouring contactors of FIG. **3**A.

FIG. **3**D depicts the effect of a spatially scheduled activation pattern on a set of consecutive actuators of FIG. **3**A that are of increasing height.

FIG. **3**E depicts a mode of construction of an alternate linear array whereby the contactor array is cut out of a single part with flexural sections.

FIG. **4**A is a plan view of a surface or area transducer depicting actuators positioned in a square grid to effect lateral x and y displacements of the contactors.

FIG. **4**B is a plan view of an alternate embodiment of the transducer with the actuators and the rods organized along a triangulated grid instead of a square grid.

FIG. **5**A is a pictorial, oblique view of the array of FIG. **4**A.

FIG. **5**B is a pictorial view depicting an alternate mode of construction of a surface display array employing a flexible membrane and contactor mounting stumps.

FIG. **5**C is a plan view of the array of FIG. **5**B which clarifies the geometrical relationships of the features of the membrane of FIG. **5**B.

FIG. **5**D is a pictorial view of the array of FIG. **5**A contained in a protective box.

FIG. **5**E is an alternate mode of construction of the contactor array wherein multiple contactors are, for portions or all of the array made of one single part.