ELECTRO-MECHANICAL TRANSDUCER SUITABLE FOR TACTILE DISPLAY AND ARTICLE CONVEYANCE

FIELD OF THE INVENTION

This invention relates to an electro-mechanical transducer for tactile stimulation and for tactile sensing. The invention as a tactile display or sensor is suited for use as a computer peripheral or any device requiring the presentation or reception of tactile sensations to or by a user including rehabilitation treatments. Specific embodiments also have applications as a micro-actuator for conveying objects.

BACKGROUND TO THE INVENTION

Devices have been built in the past to relay tactile information to a subject by mechanical stimulation distributed over a significant area of the skin, usually at the fingertip pad. Such display devices have almost exclusively relied on actuated arrays of raised pins called hereafter "indentation" devices. For example in U.S. Pat. No. 4,871,992, Petersen discloses an apparatus which combines electromagnetic transducers and cam transmissions to raise and lower pins under computer control.

Other modes of actuation have been applied to accomplish similar purposes. In U.S. Pat. No. 5,580,251, Gilkes and Cowens describe the application of polar organic gels to create computer controllable raised dots patterns. In U.S. Pat. No. 5,222,895, Fricke discloses a method to use electrorheological fluids to cause raised dots to appear on a flexible surface. A similar arrangement appears in U.S. Pat. No. 5,496,174, Garner.

Piezo ceramics have also shown great utility in achieving similar purposes e.g., U.S. Pat. No. 4,044,350 to Tretiakoff and Tretiakoff and U.S. Pat. No. 4,758,165 to Tiesmans and Zeehuisen which combines piezo ceramics with actuating cantilever reeds in a Braille cell.

Electromagnetic means are disclosed in U.S. Pat. No. 4,586,904 to Chlumsky and in U.S. Pat. No. 3,984,708 to Holmlund and Alden, as well as in U.S. Pat. No. 4,191,945 to Hannen and Charlesworth and in U.S. Pat. No. 5,583,478 to Renzi.

Recently, shape memory alloy actuators have attracted attention for similar purposes, as in U.S. Pat. No. 5,165,897 by Johnson, U.S. Pat. No. 5,685,721 by Decker, and U.S. Pat. No. 5,718,588 by Tretiakoff and Tretiakoff.

These indentation devices create sufficiently loud tactile sensations for relatively large amounts of indentation. A common design specification for such prior art devices is that they provide a quasi-static indenting displacement of the order of one millimetre of vertical displacement.

Another type of display takes advantage of vibrotactile stimulation. With this technique, an array of tactile active sites stimulates a portion of the skin using an array of contactors vibrating at a fixed frequency. This frequency is selected so as to maximize the loudness of the sensation (200–300 Hz). Tactile images are associated, not with the quasi-static depth of indentation, but the amplitude of the vibration. The Optacon™ device is one of the most well know example. Such units, however, also, rely upon indentation to provide a tactile sensation.

Finally a somewhat different principle is disclosed by Asano et al U.S. Pat. No. 5,389,849 to display tactile information by causing standing and traveling waves in a medium. Nevertheless, the medium itself is displaced vertically and provides an indentation stimulation, albeit a laterally displacing indentation stimulation.

To date, most tactile displays rely on skin indentation effected by a collection of controllable raised pins, hence the term shape displays. Thus static indentation is used as the most common mechanism to create tactile displays.

As referenced earlier, a further kind of tactile sensation can be provided, often referred to as "vibrotactile". When a contactor applies a vibratory signal to the skin at a frequency, which may range from a few Hertz to a few kilohertz, a perception is derived which may be described as "buzzing". Under certain conditions, a dense collection of vibrotactile stimulation sites may provide the sensation of a tactile image. This is principle on which vibrotactile displays operate. Vibrotactile stimulation may also be of impulsive nature.

Nearly all previous tactile display devices to date have relied on skin indentation as opposed to skin stretch to effect sensations. This present invention relies upon the lateral displacement of the skin to create tactile sensations either of shape type or of vibrotactile type. This allows new forms of transducers of convenient size and structure to be employed.

The invention in its general form will first be described, and then its implementation in terms of specific embodiments will be detailed with reference to the drawings following hereafter. These embodiments are intended to demonstrate the principle of the invention, and the manner of its implementation. The invention in its broadest and more specific forms will then be further described, and defined, in each of the individual claims which conclude this Specification.

SUMMARY OF THE INVENTION

According to one aspect of the invention a basic electro-mechanical transducer is provided which comprises in one optional simple form, at least one contactor having a contacting tip which is coupled to an associated transducer which serves as a sensor or actuation means to sense or effect lateral displacement of the contacting tip. With a sensate contacted object positioned at the contacting tip of the contactor, lateral displacement of the contacting tip by the contact actuation means will produce a tactile sensation on the sensate object. The effect of the invention is to provide a tactile sensation through the imposition of a stretching or compressing force on the skin (hereafter "skin stretch"). Thus tactile sensations are effected through a lateral displacement of portions of the skin or surface of the sensing object.

Preferably, two or more contactors are provided, particularly for tactile stimulators. Tactile display may be limited to a single location stimulated by a pair of contactors or may be provided by a tactile array: a packed array with the individual contactors being driven by a corresponding array of contactor actuators—a driving array. By providing for discrete control over individual actuators in the driving array, a variety of motions for various contactors can be provided, resulting in elaborate tactile sensations.

The contacting tips of an array of contactors may be presented in planar alignment or may be shaped in other than a planar alignment. When supported by a pre-formed substrate, these tips may conform to a shape that is ergometrically efficient or which enhances the coupling of the tips with the contacting object, usually the finger pad.

Contactors may be connected to actuators or sensors by couplings which mechanically amplify the displacements produced by the actuators or delivered to the sensors. A