APPARATUS AND METHODS FOR A SHAPE MEMORY SPRING ACTUATOR AND DISPLAY

This application is a divisional of patent application Ser. No. 09/040,871, filed Mar. 18, 1998, now U.S. Pat. No. 6,705,868 B1, which claims the benefit of priority of U.S. provisional application Ser. Nos. 60/040,518, filed Mar. 18, 1997; 60/041,876, filed Apr. 11, 1997; and 60/069,581, filed Dec. 12, 1997.

BACKGROUND OF THE INVENTION

The present invention concerns various apparatus and methods for and actuator and display using a shape memory spring. More particularly, the invention defines various apparatus and methods for imparting tactile information to visually impaired persons, especially by a computer controlled haptic display. However, certain applications of the present invention may be outside of this field.

Persons with impaired vision rely upon haptic inputs, those inputs related to the sense of touch, to receive data and appropriate that data into a network of related information. There are several different methods for providing haptic inputs. For example, visually impaired students may be taught stereochemistry through the use of three-dimensional molecular models. Also, braille has traditionally been used for representing words. Printers capable of braille embossing now have the ability to make "dot art" or pictures made up of closely-spaced braille dots. Yet another technique includes the use of tactile image paper, which is specially treated so that inked areas on the paper will rise when heated in a special machine.

The solutions thus described suffer from several drawbacks. One drawback is that the haptic information is presented in a more or less permanent form. Presentation of additional haptic information requires fabricating another haptic display, such as another molecular model or another braille-embossed sheet of paper. Another drawback is that fabrication of the additional haptic display could require considerable time. Yet a third drawback of these methods is that fabrication of the additional display may require equipment that is expensive or bulky.

The methods described are not fully compatible with the long distance, rapid communication of large amounts of data made possible by modern electronics. There is a need for haptic devices that are both computer controlled and refreshable. One approach to such a solution uses piezoelectric actuators to raise and lower an array of braille dots. Such apparatus have proven to be bulky, fragile, and costly. There is a need for a two-dimensional refreshable haptic display with reduced size, weight, and cost, and improved reliability.

SUMMARY OF THE INVENTION

The present invention provides for an apparatus that includes a first spring made from a shape-memory material. The apparatus includes an electrical power supply for heating the first spring, the electrical power supply being constructed and arranged for passing electrical current through the first spring. The apparatus includes a second spring and a member with a surface, the member defining a hole. The apparatus includes a pin urged in a first direction by the first spring after the first spring is heated. The pin is urged in a second direction by the second spring, the first direction being generally opposite of said second direction. The pin has a first position wherein a portion of the pin passes through the hole and extends beyond the surface. The apparatus includes a supporting mechanism for supporting the pin in the first position.

It is an object of the present invention to provide an improved actuator which is actuated by heating a shape-memory spring.

Other objects of the present invention will be apparent from the description of the drawings, the description of the preferred embodiment, the claims, and the drawings herein.

DESCRIPTION OF THE DRAWINGS

FIG. **1** is a diagrammatic representation of a display system according to an embodiment of the present invention.

FIG. **2** is a diagrammatic representation of a sectional cutaway of a portion of the display of FIG. **1**

FIG. **3** is a section view of a portion of an apparatus useful for heat treating a shape memory spring according to one embodiment of the present invention.

FIG. **4**A is a side perspective view of a portion of an element of a supporting mechanism.

FIG. **4**B is a top view of a portion of an element of a supporting mechanism.

FIG. **4**C is a side diagrammatic view of the element of FIG. **4**B as taken along line **4**C—**4**C of FIG. **4**B.

FIG. **4**D is a top view of an element of a support mechanism.

FIG. **4**E is a linear view of the element of FIG. **4**D as taken along arc **4**E—**4**E of FIG. **4**D.

FIG. **5** is a diagrammatic side view of a pin and supporting mechanism according to one embodiment of the present invention.

FIG. **6** is a diagrammatic side view of a pin and supporting mechanism according to one embodiment of the present invention.

FIG. **7**A is a diagrammatic side view of a pin and supporting mechanism according to one embodiment of the present invention.

FIG. **7**B is a diagrammatic side view of a pin and supporting mechanism according to one embodiment of the present invention.

FIG. **8** is a diagrammatic and schematic side view of a thermoelectric element according to one embodiment of the present invention.

FIG. **9** is a sectional view of a shape memory spring according to one embodiment of the present invention.

FIG. **10** is a sectional view of a shape memory spring according to one embodiment of the present invention.

FIG. **11** is a sectional view of a shape memory spring according to one embodiment of the present invention.

FIG. **12** is a sectional view of a shape memory spring according to one embodiment of the present invention.

FIG. **13** is a schematic of a circuit according to one embodiment of the present invention.

FIG. **14** is a schematic of a circuit according to one embodiment of the present invention.

FIG. **15** is a cross-sectional diagrammatic representation of a shape memory spring and a thermoelectric heater.

FIG. **16** is a cross-sectional diagrammatic representation of a shape memory spring and a thermoelectric heater.

FIG. **17** is a cross-sectional diagrammatic representation of a shape memory spring and a thermoelectric heater.

FIG. **18** is a diagrammatic top view of an arrangement of a shape memory spring and thermoelectric heater.

FIG. **19** is a diagrammatic top view of an arrangement of a shape memory spring and thermoelectric heater.