pad **18** (here shown as a disc with apertures or indentations at each of the four directions of the direction pad) is integrated with an elastomeric layer **82** and a printed circuit board **84** in a sub-assembly **85**. A support **86** is interposed between the elastomeric layer **82** and the direction pad **18**, where the support **86** is at least partially flexible to allow a portion **87** of the support to move down against the raised portion **88** of the elastomeric layer when the appropriate extension (or other portion) of the directional pad **18** is pressed by the user. The elastomeric layer **82** is coupled to the support **86** and the printed circuit board **84**, where a conductive portion of the raised portion **88** engages electrical contacts of the board **84** similar to the embodiment of FIGS. **2***a* and **2***b*.

Actuators **90***a* and **90***b* are coupled to the printed circuit board **84** to provide tactile sensations to the direction pad **18**. In the described embodiment, the actuators **90** are DC motors having a rotating shaft, and include an eccentric mass **91** coupled to each spinning shaft. When the masses are rotated, a tactile sensation (such as a vibration) is caused on the printed circuit board **84**. Since the directional pad **18** is part of the same assembly as the board,the pad **18** is provided with the same tactile sensation as the board **84**. To provide different-feeling tactile sensations, each actuator **90** can be controlled to produce, for example, vibrations at different frequency and/or magnitude. The combination of different tactile sensations produced by each actuator can provide a wide variety of tactile sensations. In other embodiments, a single actuator **90** can be used; in still other embodiments, three or more actuators can be provided. Furthermore, many different types of actuators can be used, as described with reference to FIG. **2***a* and **2***b*.

One example of a different actuator used with the embodiment of FIG. **3***a* is shown in FIG. **3***b*. A direction pad **18** is coupled to support **86**, which is coupled to an elastomeric layer **82** in a subassembly **92**, similarly to the embodiment of FIG. **3***a*. A printed circuit board (not shown) can also be included in the subassembly; or, switches can be self-contained in the elastomeric layer (which can be used in any of the elastomeric layer embodiments described herein). An actuator **94** having a spinning shaft **96** is coupled to the subassembly **92** by a member **98** and a vertical shaft **100**, where the rotation of the shaft **96** is converted to z-axis motion of shaft **100**. When the shaft **96** of the actuator **94** is oscillated, a vibration is imparted through the shaft **100** to the direction pad **18**. The shaft **100** can be coupled to the subassembly **92** to provide tactile sensations to the entire subassembly; or, in some embodiments, the shaft **100** can be coupled directly to the directional pad **18**. The actuator **94** shown is an E-core actuator, described in greater detail in copending provisional application No. 60/133,208; the actuator can include two coils for greater magnitude tactile sensations, or the actuator can include only one coil if space is to be conserved. In other embodiments, other types of actuators can be used.

Other types of actuators which can be used in the various embodiments disclosed herein are shown in FIGS. **3***c*, **3***d*, and **3***e*. In FIG. **3***c*, a small pager motor **104** has a rotating shaft that is coupled to a cam **106**, which is in turn coupled to a linear-moving member **108**. The member **108** is coupled to a direction pad **18** or subassembly **92**. In FIG. **3***d*, a solenoid **110** having a vertically-moving portion is shown. In FIG. **3***e*, a pager motor **112** or other actuator having a rotating shaft is shown. An actuator plug **114** has a high-pitch internal thread which mates with a pin **116** extending from the side of the rotating shaft of the motor, thus providing a low cost lead screw. When the shaft is rotating, the pin causes the plug **114** to move up or down along the z-axis **50**; when the shaft is oscillated, an appropriate tactile sensation is provided to a direction pad or subassembly.

FIG. **4** is a side elevation view of another embodiment **120** of the present invention, similar to the embodiment of FIGS. **2***a* and **2***b*. A direction pad **18** is supported by an elastomeric layer **122** on a printed circuit board **124**, similar to the elastomeric layers described above. An actuator **126**, such as a linear voice coil actuator or other type of linear actuator, provides linear motion along an axis different from the z-axis **50**. A first member **128** is coupled to actuator **126** at a first end, and is rotatably coupled to a pivoting member **130** at a second end. Pivoting member **130** is rotatably coupled to ground and may pivot about an axis C. A second member **132** is rotatably coupled to the pivoting member **130** at one end and is rotatably coupled to the direction pad **18** at a second end. The pivoting motion of the pivoting member **130** converts the motion of the linear actuator **126** to linear motion along the z-axis **50**, and provides tactile feedback to the user via the direction pad **18** along the z-axis.

FIG. **5** is a side elevation view of a different embodiment **140** of the present invention. In this embodiment, a direction pad **18** includes a number of support members **142** which extend downward from the underside of the pad. The members **142** each engage a spring member **144**, which in the described embodiment are helical compression springs and where each member **142** fits into the opening at one end of a spring. In the described embodiment, a total of five members **144** are provided, one at each of the extensions/directions of the direction pad **18** and one at the center of the pad. Likewise, there are five springs, each member **144** engaged with an associated spring. The springs **144** are coupled at their other ends to the elastomeric layer **146**, which is similar to the elastomeric layers described above. The four springs that are associated with the four main directions of the pad **18** are each coupled to an associated raised portion **148** of the elastomeric layer **146**.

When a direction of the pad **18** is pressed by the user, the pressure from the associated spring **144** presses the raised portion **148** and tab **150** down to engage the electrical contact **152** on the printed circuit board **154**. In one embodiment, the electrical contact **152** can sense the amount of pressure exerted upon it by the tab **150** and output a signal in proportion to the amount of pressure; such force-magnitude sensors are well known to those skilled in the art. The springs **144** are able to provide an amount of pressure on the contact **152** in proportion to the amount the pad extension is pressed, i.e. the degree of rotation of the directional pad **18** compressing the spring. Thus, an analog controller is provided, where the input signal to the host computer varies depending on the amount the directional pad **18** pressed in a particular direction. The springs **144** also provide upward bias to the direction pad **18** so that the pad will return to an origin position when the user removes any pressure on the pad. The tabs **145** connected to the direction pad **18** engage the housing **14** to prevent the direction pad **18** from being lifted off the housing.

The center spring **142***a* is coupled at its other end to the elastomeric layer **146** at a flat portion between the raised portions **148**, where at least a portion of the center member **144** extends into the middle of the spring **142***a*. A linking shaft **156** couples the bottom end of the center member **144** to a piezo-electric actuator **156**. The operation of piezo-electric actuators to output force based on an input electrical signal is well known to those skilled the art.

In operation, forces output by the actuator **156** is transmitted through the shaft **156** to the direction pad **18** to be felt