ferromagnetic piece and magnet. A cage **390** can be provided as the middle layer, where rollers **389** (shown as dashed lines) can be positioned within apertures in the cage **390** and allow the plate **388** to slide laterally with respect to the ferromagnetic piece and magnet. A touchpad or touchscreen (not shown) can be rigidly coupled to the top of plate **388**, with piece **382** grounded. In alternate embodiments, the touchpad or touch screen can be coupled to the piece **382** with plate **388** grounded.

[**0168**] Embodiment **380** also includes a flexible suspension, which can be coupled to the middle layer plastic cage **390** and can include two linkages **392** that are thus effectively coupled between the steel plate **388** and the ferromagnetic piece **382**. The linkages **392** contact the steel plate **388** at ends **394** and are coupled to the cage layer **390** at ends **396** (or molded with the cage layer as a single plastic piece). Each linkage includes a thinner portion **398** and a thicker portion **400**.

[**0169**] In operation, a current is flowed through coil **384** and the magnetic forces resulting from the current and magnet **386** cause the plate **388** (and the touchpad) to move as indicated by axis **402**. The suspension including linkages **392** prevents the plate **388** from skewing due to magnetic normal forces and any other forces. Each linkage **392** flexes to accommodate the motion of the plate **388**, where the thinner members **398** flex first, and the thicker members **400** flex if the limits of flex are reached for members **398**. The thinner-thicker structure allows spring centering to operate until the thicker (stiffer) beams are engaged, which provide a softer feeling stop to motion. The final limit to motion is caused by either of the stops **404** hitting the inner edge of the plate **388**.

[**0170**] The flexible suspension described above effectively allows lateral desired motion of the plate and touchpad, but prevent motion in any other direction. This creates a much more stable motion of the plate **388** and does not allow the plate **388** to drift in its position over time. Furthermore, the suspension provides a desirable spring centering force on the plate **388** and touchpad, allowing the touchpad to move to the center of its range of motion when the user stops touching and forcing the touchpad.

[**0171**] **FIGS. 17***a***-17***g* are views illustrating another flat-E actuator touchpad embodiment **420** that miniaturizes this type of actuator and provides fabricated surface mount devices that take advantage of existing lead frame and over molding manufacturing technologies. Such small scale devices can be wave soldered onto the touchpad module and can work in parallel to provide suitable stroke and force for touchpad translation (or for z-axis forces in alternate embodiments).

[**0172**] **FIGS. 17***a***-17***c* illustrate a top view of a PCB **422** which includes multiple Flat-E actuators **424**. An actuator **424** can be positioned at each comer of the PCB **422** as shown. More or less actuators than shown can alternatively be placed in other configurations. The use of multiple actuators **422** can provide greater magnitude forces and allow each actuator **422** to have a lower force output and cost. In one embodiment, the PCB **422** is a separate PCB that is grounded to the housing of the laptop. The touchpad (e.g., including its own PCB different from PCB **422**) is then coupled to the moving portions of the actuators, e.g., to the pads **426** shown in **FIG. 17***a*. In another embodiment, the PCB **422** is the touchpad, and the moving portions of the actuators are coupled to a grounded surface in the laptop, such as the housing. In such an embodiment, the actuators **424** can be hidden from the user by a lip of housing that extends around the perimeter of the touchpad, leaving the center area of the PCB **422** exposed to the user.

[**0173**] **FIG. 17***d* is a side elevational view of one end of a PCB **422**, separate from the touchpad, that includes the flat-E actuators **424**. The touchpad/PCB member **428** is coupled to the moving portions **430** of the actuators **424**.

[**0174**] **FIG. 17***e* is a perspective view illustrating one embodiment of the underside of the PCB **422** shown in **FIG. 17***a,* where the flat-E actuators **424** have been surface mounted to the underside of the PCB **422**. This can be done as "hand-placed" components, or preferably using automatic surface mount technology placement equipment. The "E" ferromagnetic piece **432** can be grounded to the PCB **422** so that the magnet and steel backing plate of the actuator move.

[**0175**] **FIGS. 17***f* and **17***g* are perspective views illustrating top and bottom views, respectively, of the flat-E actuator **424** which has **3** poles and can operate similarly to the flat-E actuators described above. Ferromagnetic piece **432** is shaped like an "E" and has a coil **434** wrapped about the center pole. Flexures **436** allow the magnet **438** and steel backing plate **440** to move relative to the ferromagnetic piece **432** and coil **434**. The touchpad (not shown) can be coupled to the steel backing piece **440** and the E-laminate piece **432**/coil **434** can be grounded, as in the embodiments of **FIGS. 17***a***-17***e*. Alternatively, the backing piece **440** and magnet **438** can be grounded and the touchpad can be coupled to a moving ferromagnetic piece **432**.

[**0176**] A flat-E actuator as described above can be used to translate touchpad modules or palm surfaces directly. In the described embodiments, the total thickness of the flat-E actuator can be about 3 mm or less. Flat-E magnetic assemblies that can be integrated into the an existing touchpad product line represent a preferred embodiment in terms of size, manufacturability and economy of scale.

[**0177**] In other embodiments, other moving magnet actuator designs, such as described in copending application Ser. No. 09/608,130, and other voice coil actuator designs, such as described in U.S. Pat. Nos. 6,166,723 and 6,100,874, can be used; these applications and patents are incorporated herein by reference in their entirety. Voice coil actuators may be thicker since the coil is positioned in a relatively large magnetic gap. Moving magnet actuators typically have smaller inherent air gaps.

[**0178**] In other embodiments, other types of input surfaces or display screens can be similarly translated using any of the actuators described herein. For example, a clear surface such as the input sensing device(s) covering a display screen of a personal digital assistant (PDA) or a touch screen on a monitor or CRT, can be similarly translated in the X and/or Y directions (parallel to the screen surface) to provide haptic feedback. One application for such clear screen translation is ATM machines, where the user typically inputs information on a touch screen. Haptic feedback can make such input more accessible and easy for people with below-average vision. Haptic feedback can indicate when the user's finger is over a graphically-displayed button, or can identify particular displayed buttons with different haptic sensations.