portion **68** is coupled to a mass **70**. Thus, when the portion **68** is moved relative to the portion **66**, the mass **70** is moved with the portion **68**. The mass **70** can be any suitable object of the desired weight, such as plastic or metal material. The mass **70** is moved approximately along the z-axis and is not coupled to the housing, allowing free motion. The motion of the mass **70** along the z-axis causes an inertial force that is transmitted through the actuator **64** to the touchpad **16**, and the touchpad **16** moves along the z-axis due to the compliant coupling **62**. The motion of the touchpad **16** is felt by the user contacting the touchpad **16** as a haptic sensation.

[**0051**] In different embodiments, other types of actuators can be used. For example, a linear voice coil actuator as described for **FIG. 5** can be used, in which an inertial mass is coupled to the linear-moving portion of the voice coil actuator. Other actuators can also be used, such as solenoids, pager motors, moving magnet actuators, E-core actuators, etc. Many actuators used for inertial haptic sensations are described in copending application Ser. No. 09/_____, entitled, "Tactile Mouse Device," filed Dec. 7, 1999, and which is incorporated herein by reference. Furthermore, a rotary actuator can be used, where the rotary output force is converted to a linear force approximately along the z-axis. For example, the rotary force can be converted using a flexure, as described in provisional application Ser. No. 60/_____, entitled, "Haptic Interface Device Providing Linear Tactile Sensations Using a Rotary Actuator," filed Dec. 21, 1999 and incorporated herein by reference.

[**0052**] In the preferred linear force implementation, the direction or degree of freedom that the force is applied on the touchpad with respect to the inertial mass is important. If a significant component of the force is applied in the planar workspace of the touchpad (i.e., along the X or Y axis) with respect to the inertial mass, a short pulse or vibration can interfere with the user's object motion in one or both of those planar degrees of freedom and thereby impair the user's ability to accurately guide a controlled graphical object, such as a cursor, to a given target. Since a primary function of the touchpad is accurate targeting, a tactile sensation that distorts or impairs targeting, even mildly, is undesirable. To solve this problem, the touchpad device of the present invention applies inertial forces substantially along the Z axis, orthogonal to the planar X and Y axes of the touchpad surface. In such a configuration, tactile sensations can be applied at a perceptually strong level for the user without impairing the ability to accurately position a user controlled graphical object in the X and Y axes of the screen. Furthermore, since the tactile sensations are directed in a third degree of freedom relative to the two-dimensional planar workspace and display screen, jolts or pulses output along the Z axis feel much more like three-dimensional bumps or divots to the user that come "out" or go "into" the screen, increasing the realism of the tactile sensations and creating a more compelling interaction. For example, an upwardly-directed pulse that is output when the cursor is moved over a window border creates the illusion that the user is moving a finger or other object "over" a bump at the window border.

[**0053**] **FIG. 7** is a top elevational view of the touchpad **16** of the present invention. Touchpad **16** can in some embodiments be used simply as a positioning device, where the entire area of the pad provides cursor control. In other embodiments, different regions of the pad can be designated for different functions. In some of these region embodiments, each region can be provided with an actuator located under the region, while other region embodiments may use a single actuator that imparts forces on the entire pad **16**. In the embodiment shown, a central cursor control region **70** is used to position the cursor.

[**0054**] The cursor control region **70** of the pad **16** can cause forces to be output on the pad based on interactions of the controlled cursor with the graphical environment and/or events in that environment. The user moves a finger or other object within region **70** to correspondingly move the cursor **20**. Forces are preferably associated with the interactions of the cursor with displayed graphical objects. For example, a jolt or "pulse" sensation can be output, which is a single impulse of force that quickly rises to the desired magnitude and then is turned off or quickly decays back to zero or small magnitude. The touchpad **16** can be jolted in the z-axis to provide the pulse. A vibration sensation can also be output, which is a time-varying force that is typically periodic. The vibration can cause the touchpad **16** or portions thereof to oscillate back and forth on the z axis, and can be output by a host or local microprocessor to simulate a particular effect that is occurring in a host application.

[**0055**] Another type of force sensation that can be output on the touchpad **16** is a texture force. This type of force is similar to a pulse force, but depends on the position of the user's finger on the area of the touchpad and/or on the location of the cursor in the graphical environment. Thus, texture bumps are output depending on whether the cursor has moved over a location of a bump in a graphical object. This type of force is spatially-dependent, i.e. a force is output depending on the location of the cursor as it moves over a designated textured area; when the cursor is positioned between "bumps" of the texture, no force is output, and when the cursor moves over a bump, a force is output. This can be achieved by host control (e.g., the host sends the pulse signals as the cursor is dragged over the grating). In some embodiments, a separate touchpad microprocessor can be dedicated for haptic feedback with the touchpad, and the texture effect and be achieved using local control (e.g., the host sends a high level command with texture parameters and the sensation is directly controlled by the touchpad processor). In other cases a texture can be performed by presenting a vibration to a user, the vibration being dependent upon the current velocity of the user's finger (or other object) on the touchpad. When the finger is stationary, the vibration is deactivated; as the finger is moved faster, the frequency and magnitude of the vibration is increased. This sensation can be controlled locally by the touchpad processor (if present), or be controlled by the host. Local control by the pad processor may eliminate communication burden in some embodiments. Other spatial force sensations can also be output. In addition, any of the described force sensations herein can be output simultaneously or otherwise combined as desired.

[**0056**] Different types of graphical objects can be associated with tactile sensations. Tactile sensations can output on the touchpad **16** based on interaction between a cursor and a window. For example, a z-axis "bump" or pulse can be output on the touchpad to signal the user of the location of the cursor when the cursor is moved over a border of a window. When the cursor is moved within the window's borders, a texture force sensation can be output. The texture