[0016] The region having a lower level of stiffness forms a deformable region, which generally coincides with the shape and location of button **20**. An actuator is coupled to the deformable region to create a haptic effect that is substantially isolated and concentrated within the deformable region. Therefore, the deformable region is the approximate region that moves through contact with the actuator.

[0017] FIG. **2** is a cross-sectional view of the rear side of surface **12** and an actuator **50** in accordance with one embodiment of the present invention. Surface **12** includes a deformable region **40** which is formed by a removal of material from the rear side of surface **12**. In one embodiment, surface **12** in regions that have not had material removed has a thickness of approximately 4.5 mm, and deformable region **40** has a thickness of approximately 1.5 mm.

[0018] Actuator **50** is coupled to the back side of surface **12** in an area other than deformable region **40**. Actuator **50** includes a stationary electromagnet **34**, a floating electromagnet **32**, and a copper coil **36**. A shaft **30** is attached to a plunger **38** and is embedded within floating electromagnetic **32**.

[0019] In a no-power condition, plunger **38** rests or is fixed against the back (non-visible side) of deformable region **40**. If plunger **38** is not fastened to the surface, a low spring force presses plunger **38** against the surface to prevent it from rattling during normal environmental conditions, such as driving a car over bump. When power is supplied to copper coil **36**, electromagnets **32** and **34** are attracted to each other, creating substantial force. This force acts against a return spring (not shown) and pushes plunger **38** (if not attached to the surface) or pulls plunger **38** (if attached to the surface) to move the surface at deformable region **40**, thereby deforming the surface to create a vibration or haptic effect. In one embodiment, the surface itself may function as the return spring.

[0020] Although actuator **50** is an electromagnetic type of actuator, any type of actuator can be used that can apply a haptic effect or force to surface **12** at deformable region **40**. For example actuator **50** may be a "smart material" such as piezoelectric, electro-active polymers or shape memory alloys. Although actuator **50** is coupled to surface **12** both inside and outside region **40** in FIG. **2**, in another embodiment actuator **50** may only be coupled to region **40**. In this embodiment, actuator **50** may be an Eccentric Rotating Mass ("ERM") in which an eccentric mass is moved by a motor, or a Linear Resonant Actuator ("LRA") in which a mass attached to a spring is driven back and forth. In another embodiment, actuator **50** may be coupled to surface **12** inside region **40** and coupled to a separate grounded element, such as a frame or structural member. Further, a controller and other necessary components are coupled to actuator **50** in order to create the signals and power to actuator **50** to create the haptic effects.

[0021] FIG. **3** is a plan view of a portion of the rear side of surface **12** in accordance with one embodiment of the present invention. Region **64** is the region where material from surface **12** was removed to create a reduced stiffness region. The remainder of the portion of surface **12** shown in FIG. **3**, region **62**, has not had any material removed. In the embodiment shown in FIG. **3**, region **64** approximately coincides with a deformable region of surface **12**, and haptic effects that are applied by an actuator coupled to region **64** will be substantially isolated within region **64**.

[0022] In another embodiment, region **64** has a tapered surface thickness forming a graduated reduced stiffness region rather than a constant surface thickness. The tapering can be formed by removing more material from the center of region **64** than from the edges in a generalized "V" shape. This creates a haptic effect that gets stronger at the center of region **64** and will produce the benefit of directing a user's finger which is on the edge of region **64** to the center of region **64**. Thus, for example, a driver in an automobile can have their finger directed to a button through haptic feedback without having to look at the button.

[0023] FIG. **4** is a plan view of a portion of the rear side of surface **12** in accordance with one embodiment of the present invention. Region **74** is the region where material from surface **12** was removed to create a reduced stiffness region. The remainder of the portion of surface **12** shown in FIG. **4**, regions **72** and **76**, have not had any material removed. In the embodiment shown in FIG. **4**, the deformable region of surface **12** is approximately surrounding reduced thickness region **74** in combination with region **76**. Thus, a portion of surface **12**, region **76**, is part of the deformable region even though it has not had material removed to form a reduced stiffness region. In the embodiment of FIG. **4**, haptic effects that are applied by an actuator coupled to region **76** will be substantially isolated within regions **74** and **76**.

[0024] In one embodiment, the appearance and state of each of the buttons **20** of FIG. **1** on the front side of surface **12** is enhanced by the addition of an electroluminescent luminescent layer and light emitting diodes ("LED's") applied on the rear side of surface **12** at the location of buttons **20**. The luminescent layer creates illumination allowing the icons for the buttons to be visible at night giving the appearance of back lighting. When a button **20** is pressed, to provide further feedback to the user, LEDs may be turned on or off to indicate the state of a device controlled by a button, for example the level of heat for a heated seat.

[0025] Although embodiments disclosed above are of an automotive dashboard, the present invention can be implemented on a surface of any other type of device where isolated haptic effects are desired. Other embodiments can include aircraft buttons, buttons on appliances such as refrigerators, and buttons on medical devices where cleanliness concerns dictate having a smooth button surface. In another embodiment, rather than having an icon or other indicator of the presence of the button, the button is unmarked. This embodiment is useful for creating a hidden wall switch where the button is undetectable except when it is pressed and the isolated haptic effect is generated. In addition, features other than buttons can be designed with these localized haptics effects. Such other features can be, for example, a haptically enabled surface representing a linear slider, a curved slider or a circular slider. The slider would allow a user to move a finger along the haptic enabled surface such as to select from a table or to set a volume level.

[0026] As described, embodiments of the present invention create an isolated haptic effect which creates many advantages. Because the haptic effect is isolated, it is stronger and thus can be more easily felt through, for example, a driving glove. Further, multiple buttons **20** of FIG. **1** can be pressed at the same time without having the haptic effect from one button bleeding over to the other button, and each button can be separately discernable by the user. Embodiments of the present invention allow much greater design