

mass 68. The lever 66 may be long enough that small upward or downward movement the distal end of the lever 66 is nearly perpendicular to the plane of the touch screen 12. Moving the mobile phone 10 and accelerometer module 50 in a “Y” direction (right and left on the page as shown) or in an “X” direction (in and out of the page) will not induce any deformation of the ball 60. Only movement that is substantially vertical with respect to the touch screen will cause deformation of the ball 60. A coil spring 70 is disposed about the pivot axis of the pivot pin 64 and has one leg that biases the lever toward the touch screen by pushing a second leg against a tab on the support bracket 62.

[0046] In FIG. 7A, the deformable ball 60 is in relaxed contact with region 46 of the touch screen 12. The relaxed contact produces a contact area having a diameter D1. This contact area is sensed by the touch screen 12 and provides the contact area associated with the region 46 to the processor.

[0047] In FIG. 7B, the deformable ball 60 is in deformed contact with the touch screen as a result of vertical movement of the accelerometer module 50. The deformed ball produces a contact area having a diameter D2, wherein deformed diameter D2 (and the deformed contact area) is greater than the relaxed diameter D1 (and the relaxed contact area). The application program or operating system of the mobile phone receives this information and uses the contact area as an indicator of an amount of acceleration being applied in the vertical direction.

[0048] FIGS. 8A-C are partial cross-sectional views of a second mechanism 58 for measuring force in a “Y” direction with a deformable ball 72 in slightly deformed contact with a different region 44 of the touch screen 12 under the force of a spring 74 (FIG. 8A), greatly deformed contact caused by movement of the module 50 to the right (FIG. 8B), and in relaxed contact caused by movement of the module 50 to the left (FIG. 8C), respectively. The second mechanism 58 includes a right-angled or L-shaped lever having a first leg 76 that extends substantially perpendicular to the plane of the touch screen to support a mass 78 and a second leg 80 that extends substantially parallel to the plane of the touch screen. The L-shaped lever pivots about an axis that is parallel to the plane of the touch screen and aligned with the X-axis (in and out of the page). Accordingly, movement of the accelerometer module 50 in the X-direction or the Z-direction will not induce any deformation of the ball 72.

[0049] In FIG. 8A, the ball is slightly deformed by the force of the spring 74 to produce a contact area D3. In FIG. 8B, the module 50 is moved to the right resulting in further deformation of the ball 72 and producing a larger contact area D4. In FIG. 8C, the module 50 is moved to the left resulting in less deformation of the ball 72 and producing a smaller contact area D5. The application program or operating system of the mobile phone receives this information and uses the contact area as an indicator of an amount of acceleration being applied in the Y-direction. Unlike the mechanism 56 of FIGS. 7A-B which could only detect one direction of movement along an axis (i.e., upward movement in the +Z direction), the mechanism 58 of FIGS. 8A-C provides sufficient information to sense movement two directions along an axis. Movement to the right (i.e., in the +Y direction) causes a contact area that is greater than the contact area when the accelerometer is stationary. Movement to the left (i.e., in the -Y direction) causes a contact area that is less than the contact area when the accelerometer is stationary. The degree of movement or acceleration may be determined as well as the direction,

because the degree of increase or decrease in the contact area is sensed by the touch screen and provided to the processor. It should be recognized that the first mechanism 56 may also be implemented to detect movement in two directions by increasing the force of the spring 70.

[0050] It should also be recognized that a third mechanism 54 (as shown in FIG. 6) may be provided in the same manner as the second mechanism 58, except that it is secured to the module at a right angle to the second mechanism 58. Specifically, the third mechanism 54 has a pivot axis that is parallel with the Y-axis such that it only senses movement in the X-direction. Furthermore, the third mechanism 54 makes contact with the touch screen 12 in a different predetermined region 42 so that the processor can determine whether the force is attributable to the X, Y or Z axis.

[0051] FIGS. 9A-D are side views of deformable members that would provide different relationships between force and contact area, regardless of the type of mechanism or axial component of force being sensed. In FIG. 9A, a triangular or pyramidal member 82 is mounted to a lever 83 and presents a point or vertex onto the touch screen 12. The vertex would be expected to initially produce a very small contact area and require less force to deform than a sphere. In FIG. 9B, a spherical section 84 is coupled to a lever 85 and presents a spherical surface against the touch screen 12. The spherical section 84 should produce a similar relationship between force and contact area as a complete sphere, but will require less space because it is thinner and will require less angular displacement of the lever. In FIG. 9C, an irregularly shaped member 86 is coupled to a lever 87 and illustrates that, for any given material, a profile may be modified to produce a desired relationship between force and contact area. In FIG. 9D, a hollow member 88 is coupled to a lever 89, where making the member hollow may result in a greater contact area during deformation since there is no internal material to compress or stretch. Such a hollow member may be perforated or air tight.

[0052] FIG. 10 is a partial perspective view of the first mechanism 56 with a coil spring 70 that biases the lever 66 toward the touch screen 12 to prevent loose swinging of the lever and maintain contact between the deformable member 60 and the touch screen 12. As previously discussed, embodiments of the spring 70 may partially deform the member 60 to enable detection of both upward movement via increases in contact area and downward movements via decreases in contact area. The coil spring 70 will typically have one or more turns or coils and two legs that project outward to engage the lever 66 and the support bracket 62, such as against a tab 63.

[0053] FIGS. 11A-B are partial cross-sectional views showing potential attachment of a deformable member to a lever. In FIG. 11A, a deformable member 90 takes the shape of a hollow sphere and is coupled to the lever 92 by a rivet or other fastener 94. In FIG. 11B, a spherical section 96 includes tabs 98 for coupling to the lever with rivets or other fasteners 94. It should also be recognized that the deformable members may be secured using adhesives or other attachment means.

[0054] FIGS. 12A-C are partial cross-sectional views of embodiments using a tubular or cylindrical chamber to hold the deformable member, mass, and spring in a manner so that acceleration in a particular direction causes deformation against the touch sensitive device. In FIG. 12A, the module 50 includes a mechanism 140 forming a tubular chamber defined by walls 142. The chamber walls 142 secure the deformable member 60, the mass 68, and a spring 144 in alignment. Accordingly, acceleration of the module in the +Z direction