level acceptable for use in a touch locating application. Other provisions for improved linearity may also be made, as described below.

[0054] A force sensor has a direction of sensitivity, such that a translational force of given magnitude creates greatest output when applied in that direction, and no output when applied at right angles to that direction. A displacement sensor has an analogous direction of sensitivity with respect to applied pure translational displacements. A force sensor is said herein to have an axis of sensitivity that passes through its elastic center in its direction of sensitivity. A displacement sensor may be taken to have an axis of sensitivity lying in its direction of sensitivity, and so located that relative rotation of the two sides about points in the axis tend to produce no output.

[0055] It is desirable that a force sensor have a precisely determined axis of sensitivity, and that this axis be easily and precisely aligned, as desired, with respect to the enclosing application. The thin, planar nature of the sensor provided in various embodiments of the invention satisfies this need naturally. It is also desirable for the force sensor to be unresponsive to any moment couples passing through it. For a force sensor comprising a displacement sensor sensing the displacement across an elastic means, this requires that the displacement sensor's axis of sensitivity pass through the elastic center of the elastic means. Sensors provided in various embodiments of the invention accomplish this goal by making the principal element and its contacts symmetrical under a 180 degree rotation about the axis of sensitivity.

[0056] Potential moment sensitivity may be further reduced by providing a rotational softener at the loading contact. A bump, or other elevated central feature in the principal element, may serve as a pivot providing this function. Locating this feature in the principal element itself has the further advantage of providing the force sensor with a determined sensitivity. When force is transmitted from an overlying surface contacting the bump, changes in relative alignment leave the region of load transmission unchanged with respect to the force sensor.

[0057] Forces and moments may be transmitted through a sensor that are not those the sensor is intended to measure. If the sensor is not perfectly constructed and aligned, it may have some sensitivity to these, leading to errors of measurement. In addition, unmonitored forces and moments may be part of a pattern including monitored forces, such that the equations for locating touch may not be evaluated accurately without measurements of the full pattern being available.

[0058] Various aspects of the invention provide for the reduction or elimination of these unmonitored forces or moments.

[0059] In a first aspect, embodiments of the invention may employ a rotational softening means to reduce or eliminate moments transmitted through a force sensor. In one embodiment, such a rotational softener may comprise a soft elastic body, such as a small elastomeric slab, or a stiffer element, such as a portion of a metal stamping, bent or prolonged in the direction of sensitivity. In another embodiment, it may comprise a pivot, operating without receptacle against a hard surface, or with self-forming receptacle, against a softer surface.

[0060] One benefit of rotational softening may obtain where the touch surface structure is not fully rigid, such that some small local flexure occurs near a point of touch. Such local flexure may lead to substantial touch location error, even with perfectly constructed and aligned sensors, if the sensor on its support from below is not substantially softer in rotation than the attachment offered from above by the touch surface structure. In effect, a sensor connection with excessive rotational stiffness can support a nearby touching finger in part by using the intervening portion of the touch surface structure as a cantilever, thereby obtaining more of the perpendicular force than would be ideally presumed. A distortion of the position of reported touch locations results, which distortion is sensitive to details of the stiffness relationships. Rotational softening may be employed to prevent the appearance of such a pattern combining unmonitored sensor moment with balancing spurious perpendicular force components.

[0061] Rotational softening may thus be of particular benefit when used with a touch surface structure that is thin and flat, and thus comparatively flexible, such as a flat overlay plate of minimal thickness.

[0062] Another benefit of rotational softening may obtain where the sensors are not perfectly constructed. Such sensors may give spurious responses to transmitted moments. A rotational softener may offer greatest reduction of the moment actually experienced by a force sensor, if it is located as close as possible thereto. This reduces the production of sensor moment in response to any lateral forces transmitted. Thus rotational softening achieving the benefits of the invention may be applied away from the plane of touch, and may be applied close to the force sensors.

[0063] In a second aspect, embodiments of the invention may employ a lateral softening means to reduce or eliminate forces transmitted through a force sensor at right angles to its nominal axis of sensitivity. In one embodiment, such a rotational softener may comprise an elastic body, such as a small elastomeric slab. In another embodiment, it may comprise a pin, column, or ball, offering a pair of pivots, softly elastic ends, or rolling surfaces offset from each other by at least a small distance.

[0064] One benefit of rotational softening may obtain where tangential forces applied to the touch surface are prevented from developing a pattern of forces, such pattern combining spurious perpendicular sensor forces with lateral sensor force and moment to maintain overall equilibrium, as described in more detail below.

[0065] Another benefit of lateral softening may obtain where the sensors are not perfectly constructed. Such sensors may give spurious responses to forces at right angles to their nominal axis of sensitivity. Lateral softening may also reduce extra sensor moment potentially generated by such lateral forces, where the associated elastic center is not in the sensor center.

[0066] Combinations of lateral softening, rotational softening, and lateral stiffening may serve to establish necessary axes of sensitivity more accurately than can be achieved through the construction of the sensors themselves. This follows in part from the large area over which the alignment of the plane of effect of the lateral stiffening means may be established.

[0067] Many alternative embodiments of lateral and rotational softening means will be evident to those of ordinary skill in the art, and are within the scope of the invention.