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(12) **United States Patent**
**Fish**

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(54) **FORCE FEEDBACK COMPUTER INPUT AND OUTPUT DEVICE WITH COORDINATED HAPTIC ELEMENTS**

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( * ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/357,727**

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(52) **U.S. Cl.** ..... **345/156**; 345/173
(58) **Field of Search** ..... 345/161, 156, 345/157, 158, 173–179, 163

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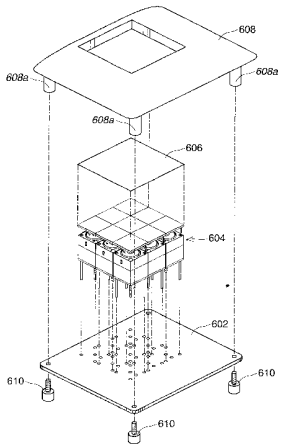
(57) **ABSTRACT**

A set of haptic elements (haptels) are arranged in a grid. Each haptel is a haptic feedback device with linear motion and a touchable surface substantially perpendicular to the direction of motion. In a preferred embodiment, each haptel has a position sensor which measures the vertical position of the surface within its range of travel, a linear actuator which provides a controllable vertical bi-directional feedback force, and a touch location sensor on the touchable surface. All haptels have their sensors and effectors interfaced to a control processor. The touch location sensor readings are processed and sent to a computer, which returns the type of haptic response to use for each touch in progress. The control processor reads the position sensors, derives velocity, acceleration, net force and applied force measurements, and computes the desired force response for each haptel. The haptels are coordinated such that force feedback for a single touch is distributed across all haptels involved. This enables the feel of the haptic response to be independent of where touch is located and how many haptels are involved in the touch. As a touch moves across the device, haptels are added and removed from the coordination set such that the user experiences an uninterrupted haptic effect. Because the touch surface is comprised of a multiple haptels, the device can provide multiple simultaneous interactions, limited only by the size of the surface and the number of haptels. The size of the haptels determines the minimum distance between independent touches on the surface, but otherwise does not affect the properties of the device. Thus, the device is a pointing device for graphical user interfaces which provides dynamic haptic feedback under application control for multiple simultaneous interactions.

**12 Claims, 9 Drawing Sheets**



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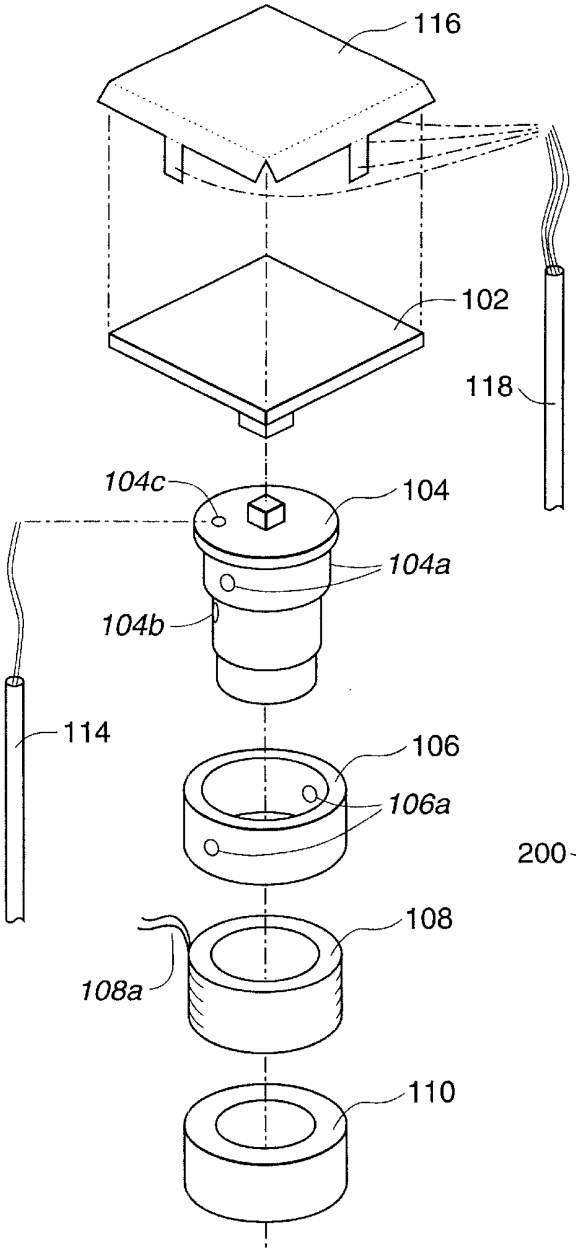


Figure 1

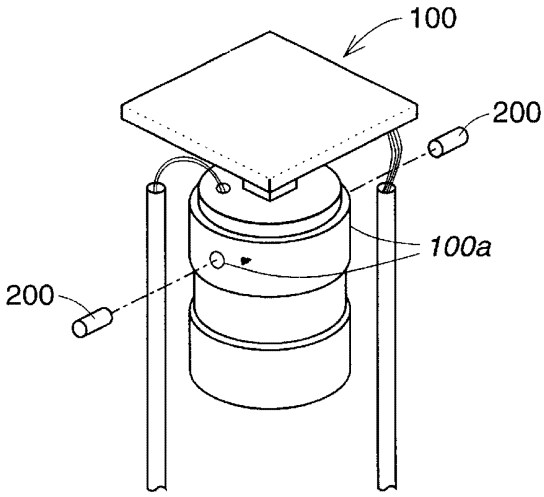


Figure 2

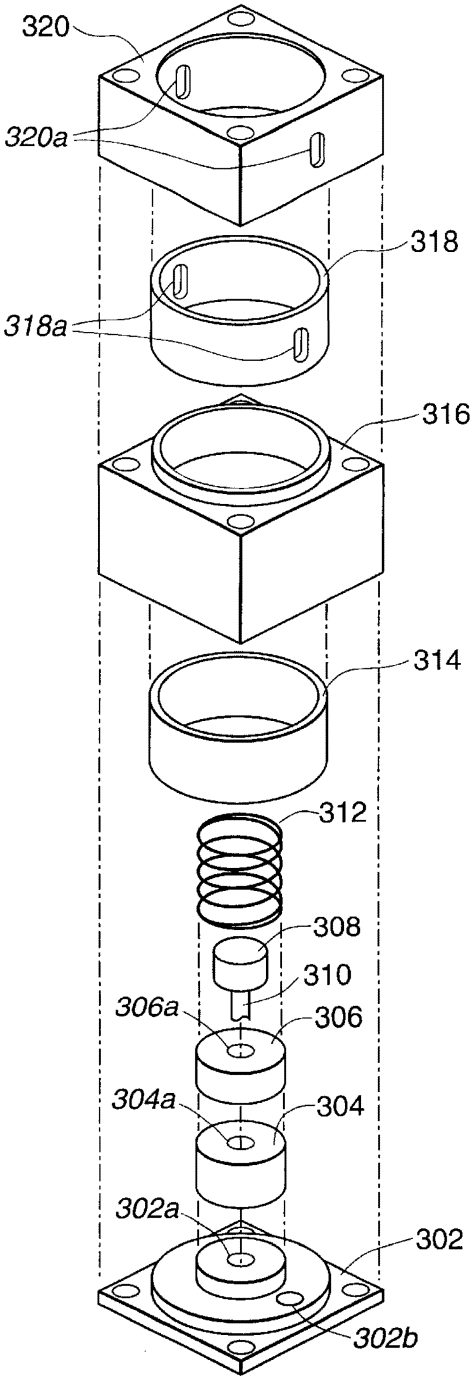


Figure 3

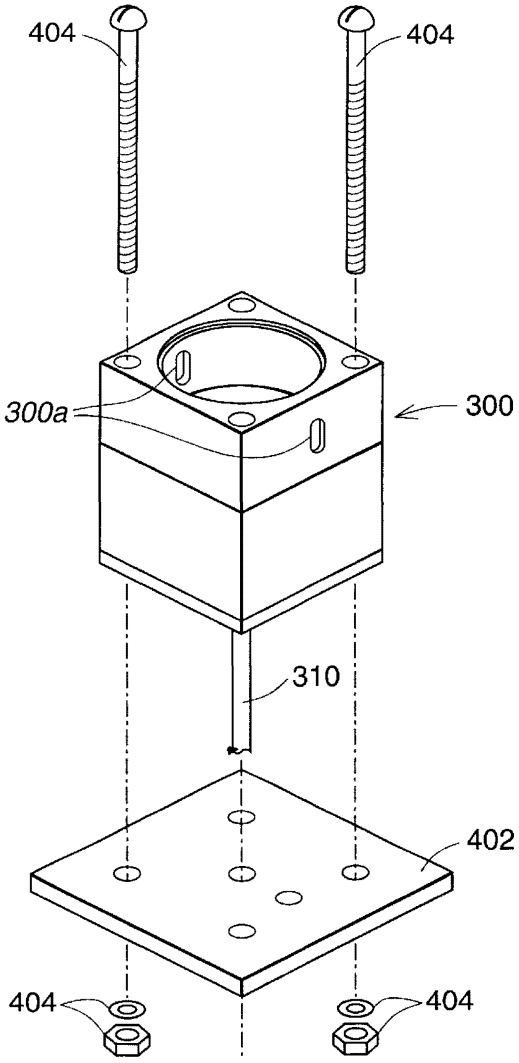


Figure 4

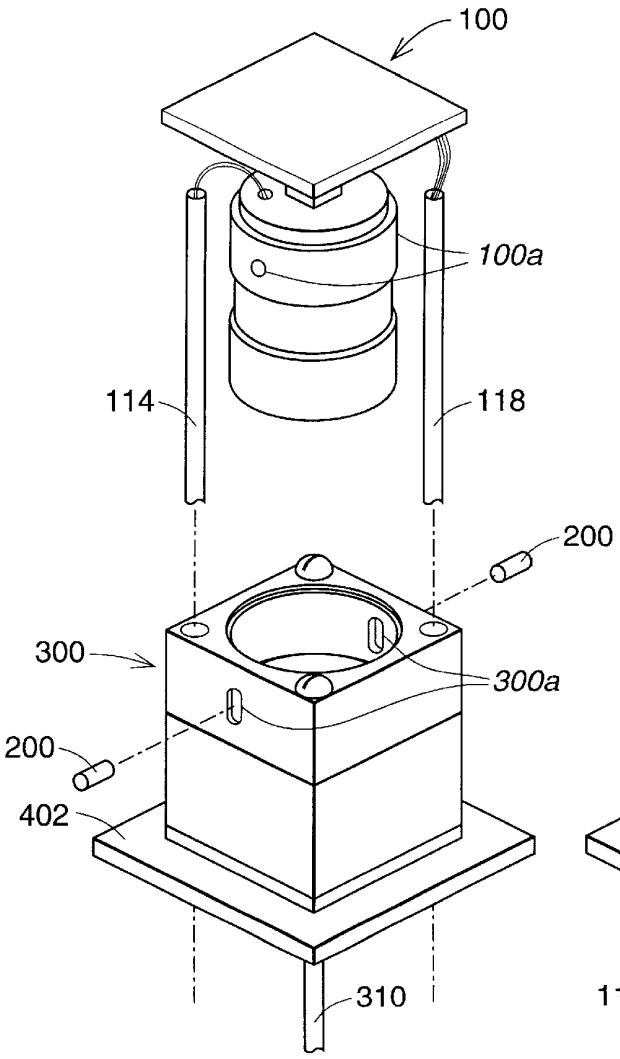


Figure 5A

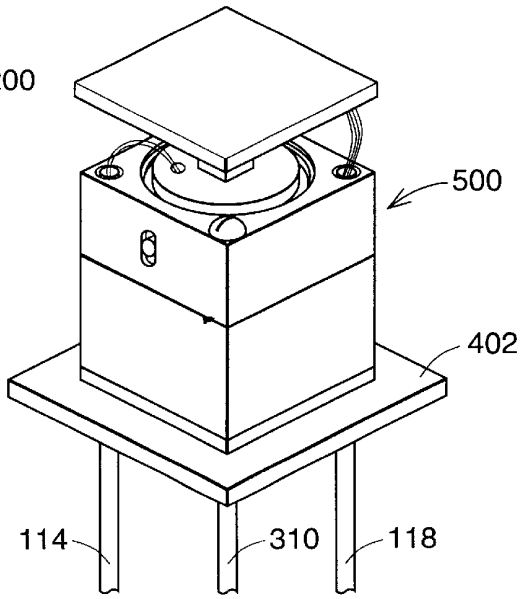


Figure 5B

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