having printed or otherwise supported electrically conductive sensors and associated screened or printed circuitry as is now commonly used in many computer keyboards. The electrically conductive sensors may be contacts defining on/off switches, or variable output sensors such as pressure sensitive resistors as are being developed by myself. The sheet supported sensors of the preferred embodiment allow ready low-cost integration into a modern computer keyboard, hand-held remote, stand alone controller or other like structure.

The sensors are positioned for sensing moment of the handle relative to the housing and creating moment related information usefully indicative of the handle status relative to the housing.

For the purposes of this specification and claims, the term "moment" is being utilized as meaning status, or direction, indicated in terms of either position or pressure. Moment is primarily an indication of the status of the handle: what direction it is moved, and in that direction how far positionally it is moved, or how intensely it is pressed relative to the housing. These terms defining "moment" are somewhat dependent upon type and sophistication of the sensors utilized, and a variety of sensors may be utilized with the present invention. For example, simple on-off contact sensors indicate the direction moved but only if moved a significant amount positionally sufficient to activate the sensor, and the on-off contact sensor provides information describing whether significant movement has been made or not, which in either case is valuable and useful information in part establishing the information state of the controller. More sophisticated proportional sensors such as variable resistive pressure sensors, or potentiometers and optical positional sensors, indicate direction and position or force. A pressure sensitive sensor provides information describing direction and intensity of handle movement or pressure relative to the housing, thus in part establishing the information state of the controller. Additionally, some types of proportional sensors coupled with return-to-center resilient structure may respond to a combination of position and pressure with one characteristic being dominant or more meaningful to output. The term "moment" is essentially a word indicating a significant event, status, current position, and/or pressure exerted.

For the purposes of this specification and claims, the term "sensor" or "sensors" is considered to include but not be limited to variable resistive pressure sensors, proximity sensors; capacitive sensors, piezo sensors, variable voltage/amperage limiting or amplifying sensors and switches, potentiometers, resistive and optical encoders and simple on/off switches.

For the purposes of this specification and claims, the terms "significant" or "significantly" are defined as being sufficient and necessary movement or force to actuate a sensor, excluding simple part tolerance or clearance for allowing desired movement of mechanical parts. For example, if a shaft must tilt in order to actuate a sensor, then that shaft is said to be "significantly" tiltable, and alternatively if a shaft tilts slightly due to part clearances (tolerances) and is not designed or required to tilt in order to actuate a sensor, then the shaft is "significantly" non-tiltable.

OBJECTS AND ADVANTAGES

With the present invention, there exists no requirement that the housing be moved, unlike a 6 DOF glove for example, and this aspect renders many advantages, these advantages being enhanced by the use of sheet surface supported or defined sensors in many applications. For example, the movable carriage supporting the handle may be built into or attached onto an otherwise conventional computer keyboard; built into a hand held television style wireless remote control device; built into the arm of a chair, or it may be built into a housing specific for the carriage and handle, and one which is structured to rest upon a support surface such as a table or desk when utilized to serve as a stand-alone or peripheral unit, etc.

The present invention while offering superior function and feel to the user, also allows replacement of higher cost components and labor for much lower component and labor costs, as the high cost of related devices has been a problem for sales of prior art devices to the average computer user, and the average television viewer. The preferred mounting or defining of sensors on a sheet surface allows utilizing highly automated and efficient modern manufacturing processes which eliminate or greatly reduce the requirement of hand applied individually insulated conductors (wires). For a 6 DOF controller to be truly useful to society, it must be affordable for the common user to purchase. As will become increasingly appreciated with continued reading, the present invention is structured to offer superior function and feel to the user at very low-cost.

The use of sheet surface supported or defined sensors allows the controller to have a low profile, and further particularly in regard to the handle, allows for the installation of an electro-mechanical device such as a motor or solenoid within the handle to provide non-passive feedback to the user without rendering the handle excessively large or akward.

A primary object of the invention is to provide an improved hand manipulated 6 DOF controller primarily for use in controlling or at least assisting in controlling graphic images such as those displayed by a computer, television display, head mount display or heads-up display, and the like.

check the below object for accuracy and consistency pertaining to the use of "pure" in the above prior art section.*

A further object of the invention is to provide a 6 DOF controller which includes structuring allowing pure separate interpretations for the linear related information states to represent only linear hand input, not including even a small or significant degree of arcing or rotational hand input. Likewise the structuring allowing for the rotational related information states to represent only rotational hand input, not including even a small or significant degree of linear movement hand input. Clearly, a 6 DOF controller having "pure-separate" function is preferable so as to provide a "true" 6 DOF controller absent cross-talk and cross-coupling related problems.

A further object of the invention is to provide a 6 DOF controller which allows for the application and advantage of sensor choice. This invention is an input device that has physical manifestations that can stimulate any of various types of useful sensors. The invention can be constructed with sensors as inexpensive as simple electrical contacts or more sophisticated proportional sensors such as positional or pressure reading sensors, or the like.

A further object of the invention is to provide a 6 DOF controller which preferably includes resilient structuring providing a self centering or return to a center null position of the controller structuring regarding linear movements, and further, wherein there exists a small degree of "play" between sensor activation which helps compensate or provide a degree of forgiveness for small unintentional hand movements on the controller.

A further object of the invention is to provide a 6 DOF controller which preferably includes a detectable feedback, felt by the user's hand or possibly audibly detected, which indicates that the handle has moved sufficiently from the null position to activate a given sensor.

A further object of the invention is to provide a multi-axis controller which can also be useful as an improved two or three axis controller in addition to or replacing the function of the arrow keypad on a typical computer keyboard and also possibly the page-up and page- down keys of the keyboard.

A further object of the invention is to provide a 6 DOF controller which preferably includes structuring which may be manufactured utilizing modern and efficient techniques and components so as to achieve low-cost manufacturing.

Another object of the invention in furtherance of achieving low cost manufacturing is providing sheet supported sensors in either a multiple layer membrane sensor structure or alternatively efficient use of circuit board supported sensors, thus greatly reducing or eliminating labor intensive, high cost hand wiring.

Another object of the invention in furtherance of achieving low-cost manufacturing is provided by use of sheet supported sensors which allow extremely low-cost integration of a multiple axes controller into devices already having onboard intelligent circuitry such as computer keyboards and hand held remote control devices. Many keyboards typically already use membrane supported sensor layouts which can be readily modified to accommodate the current invention, thus the invention can be incorporated into such a keyboard or device for little more than the cost of a few small injection molded parts.

These, as well as further objects and advantages of the present invention will become better understood upon consideration of the remaining specification and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is an exploded perspective view a first preferred embodiment of the invention.

Fig. 2 is a side view in partial cross section of the first embodiment.

Fig. 3 being of the first embodiment, is a perspective view of a portion of the carriage, shaft, a shaft pin, rocker-arm actuators, sheet surface with sensors, the sensors being hidden under force feedback dome caps.

Fig. 4 illustrates a first configuration of rocker- arm actuator positioned to actuate two different types of sensors shown for illustrative purposes. Fig. 5 illustrates a second configuration of rocker- arm actuator indirectly coupled to the lower end of the shaft and positioned to be capable of actuating two sensors.

Fig. 6 illustrates a third configuration of rocker- arm actuator indirectly coupled to the lower end of the shaft and positioned to be capable of actuating two sensors.

Fig. 7 illustrates a portion of the carriage from a top viewing showing optional rocker-arm lay-out involving a forth type rocker-arm actuator.

Fig. 8 being a simplified view, shows a partial cross section of the lower portion of the carriage of Fig. 7 from a side view showing operation of the forth type rocker-arm actuator.

Fig. 9 shows an exploded view of the handle at the upper end of the shaft.

Fig. 10 shows a perspective view of a multiple-layer membrane sheet surface supporting a plurality of sensors and conductive traces, and custom shaped to integrate a 6 DOF controller into a computer keyboard or hand held remote control.

Fig. 11 shows a typical prior art computer keyboard having an arrow keypad.

Fig. 12 shows modified computer keyboard with a multiple-axes controller replacing the arrow keypad.

Fig. 13 shows in a perspective view, a stand-alone peripheral multi-axes controller generally in accordance with present invention and with an optional ergonomic design shown in broken lines.

Fig. 14 shows a hand held remote control device with an integrated multi-axes controller.

Fig. 15 shows the first, second and third axes mutually perpendicular to one another, and intersecting one another proximal to a center of the handle.

Fig. 16 shows a bifurcating metal sensor in cross section and in an open state (off).

Fig. 17 shows the sensor of Fig. 16 in an actuated or closed state (on).

Fig. 18 shows a cross sectional view of a dome cap on a circuit board having interlaced conductive traces to be closed by a conductive disk inside of the dome cap.

Fig. 19 shows in cross section, a three layer membrane defining a single momentary-on switch structure, the switch in the open state (off).

Fig. 20 shows in cross section, a three layer membrane defining a single momentary-on switch structure in the closed state (on).

Fig. 21 shows a standardized right-angle mount mechanical momentary-on switch, shown in partial cross section.

Fig. 22 shows a version of the switch of Fig. 21, only in a flat mount position, and modified to include a pressure sensitive variable resistor component.

Fig. 23 shows a circuit board in cross section, supporting interlaced conductive traces contacting a pressure sensitive variable resistor component.

Fig. 24 shows in cross section, a commonly available pressure resistive sensor in plastic sheet membrane with a resilient dome cap actuator.

Fig. 25 shows yet another sensor, being a three layer membrane including a pressure sensitive variable resistor component sandwiched between opposing electrical traces on the two outer membranes.

Fig. 26 shows the sensor of Fig. 25 in an actuated state.

Fig. 27 shows a portion of the carriage having two bi-directional slide potentiometers.

Fig. 28 shows a modified rocker-arm actuator driving a geared bi-directional rotary potentiometer.

Fig. 29 shows a modified rocker-arm actuator driving a bi-directional optical sensor. Fig. 30 shows a partial view of sensors within the handle showing one version of a geared bi-directional potentiometer on one axis, and on a second axis is a bi-directional sliding optical sensor.

Fig. 31 shows a partial cross section of a second preferred embodiment from a side view.

Fig. 32 shows a perspective view of the lower end of the shaft of the second embodiment.

Fig. 33 shows a side view of the lower end of the shaft of the second embodiment.

Fig. 34 shows a perspective bottom view of the carriage with sensors of the second embodiment.

Fig. 35 shows a graph of a common prior art force feedback.

Fig. 36 shows a graph of another prior art force feedback.

Fig. 37 shows a graph representing a force feedback having a threshold useful in the present invention.

BEST MODES FOR CARRYING OUT THE INVENTION

Although I herein very specifically describe best modes and preferred structures and use of the invention, it should be understood that many changes in the specific structures and modes described and shown in my drawings may clearly be made without departing from the true scope of my invention.

One preferred embodiment is shown in figures 1-9. Referring to Figure 1, a hand manipulatable handle 100 is shown supported on a shaft 102. Shaft 102 extends into a base assembly or housing 217. Shaft 102 passes thru a shaft guide first main hole106 within a sliding plate or platform called a first platform 352. Shaft 102 further passes thru a shaft guide second main hole 110 located in a second platform 222. Figure 2 shows Platform 222 fixedly attached to connecting structure shown as legs 112 which are fixed to first platform 352, thus platform 222, connecting structure 112 and platform 223 cooperate together forming the structure of a carriage 114.

First platform 352 is slidably retained along a first axis by a sliding plate called an anti-rotating plate 350 which is slidably retained along a second axis by at least one housing guide 108 which is fixed to housing 217. First platform 352 and plate 350 are further constrained by retaining shelf 216 and housing 217 from movement along a third axis. Thus plate 350, guide 108, housing 217, and shelf 216 cooperate to form a carriage support structure 116 in which platform 352 (and thus also carriage 114) is prohibited from significantly rotating on any axis, and also is allowed to move significantly along the first and second axes but is prohibited from significant movement along the third axis, relative to housing 217.

Within carriage 114, and platforms 352, 222, holes 106, 110 cooperate to offer sufficient fit in the passage of shaft 102 to provide advantageous structural cooperation in two substantial ways. The first is the provision of an anti-tilting structure124 which prevents shaft 102 from significant tilting (rotating about the first or second axes) relative to carriage 114. The second is provision of two-axes structure where any and all linear movement along parallel to the first and second axes by shaft 102 is coupled to equivalent movement along parallel to the first and second axes of carriage 114.

A second endward region 120 of shaft 102 as shown in figure 2 is shaped with a male partial spherical shape 218 which slideably contacts a complimentary female partial spherical shape 240 which is part of handle 100, and region 120 of shaft 102 also comprises a male pivot protrusion 246 having a pivot or rotational point located approximately central to handle 100 and approximately at the center of the spherical partial section shapes. Protrusion 246 provides a handle 100 pivot point and may mate to a female pivot receptacle 248. Thus handle 100 can be rotational relative to shaft 102 yet coupled for all linear movement along parallel to the first and second axes with equivalent linear movement of shaft 102 and also two-axes structure 126, therefore the above mentioned members connecting handle 100 to shaft 102 and shaft 102 to carriage

114 serve as a handle support structure 128 in which handle 100 is coupled for equivalent movement with carriage 126 along parallel to the first and second axes.

On carriage 114 are rocker-arm structures 124 shown mounted on second platform 222. Rocker-arm structures 124 convert movement of carriage 114 relative to housing 217 to a resilient thermoplastic rubber (TPR) sheet 128 formed with a plurality of resilient dome cap 128 structures. Resilient sheet 126 and second platform 222 sandwich sensors as shown in Figs. 1-3 and others, as a membrane sensor sheet structure130. Rocker-arm structures 124 have at least a mounting structure 132, a fulcrum 134, at least one sensor acutating arm 136, and an activating structure 138. Structure 138 is the distinctive part of the different two armed rocker-arm types shown in Figures 1 and 3, of which are a V-slot type 140, an H-slot type 142, and a T-bone type of which there are two rocker-arms being approximately identical but oriented perpendicular to one another and being called a first t-bone 144 and a second t-bone 146 rocker-arm actuators. Figure 7 shows the space savings in the area of second platform 222 which also may be a rigid circuit board sheet? This space savings may be valuable in tightly constricted areas such as integration of the invention into computer keyboards and hand held remote control devices. The second platform 222 layout of Figures 1-3 is shown in the larger dotted line? with the newer smaller platform 222 shown by solid line ? and first t-bone rocker-arm has been divided into two separate one-armed type ? actuators each with its own mount 132, fulcrum 134, sensor arm 136, and activating part 138 as shown in figure 8.

Understanding the action of one rocker-arm structure conveys much understanding of all rocker-arm structures to one skilled in the art, so in the interest of brevity rocker-arm structure and functionality will only focus on the unique parts of each different rocker-arm structure.

A shaft pin 122 is fiixed within shaft 102 passing thru a first endward region 118 approximately perpendicular to shaft 102. A first end of shaft pin 122 passes thru a beveled slot within activating structure 132 of rocker-arm H-slot type 142 in which the slot is approximately perpendicular to the third axis and the length of shaft 102, so that when shaft 102 and shaft pin 122 move along the third axis rocker-arm 142 in moved in kind with one arm descending to compress its respective resilient dome cap 128 and upon collapse of dome cap 128 the respective underlying sensor is acutated, as shown in figure 5. Of course movement of shaft 102 in the opposite direction along the third axis likewise actuates the opposite complimentary sensor of the sensor pair. Rotation within operational limits of shaft 102 about its cylindrical center or approximately about the third axis simply causes shaft pin 122 to move within the slot and does not activate the H-type rocker-arm 142.

A second end of shaft pin 122 passes thru a slot of a rocker-arm structure of the V-slot type 140 which is activated in the converse of the above type 142 rocker arm Movement of shaft 102 along the third axis simply causes shaft pin 122 to move within the slot and not actuate V-type rocker-arm 140, but rotation about the third axis causes shaft pin 122 to activate rocker-arm 140 in the corresponding manner as shown in figure 6 with dashed lines indicating a rotational motion of shaft 102 conveyed to shaft pin 122 which activates rocker-arm 140 causing compression of a dome cap and stimulation of a sensor located on a membrane. Figure 3 shows activating part 138 of rocker-arm 140 to have a slot in structure slanting away from shaft 102. This is to accomodate the increasing moment arm as pin 122 changed distance from fulcrum 134 when shaft 102 is moved along the third axis. Thus the slope of slot compensates for varying distance of shaft pin 122 so that rotation of shaft about the third axis causes rotationally equivalent activation of rocker-arm 140 regardless of the distance shaft pin 122 is from fulcrum 134 of rocker-arm 140.

Although I have very specifically described best modes and preferred structures and use of the invention, it should be understood that many changes in the specific structures and modes described and shown in my drawings may clearly be made without departing from the true scope of the invention.

Abstract of the Disclosure

A hand-operated graphics controller having up to six degrees of freedom (6 DOF) for converting human hand input manipulations of a handle into electrical information states representative of the input manipulations. A preferred embodiment includes the handle operable relative to a housing. Handle operation is mechanically resolved to twelve sensors or six pairs of sensors for bidirectional interpretion of handle movement along and rotation about three mutually perpendicular axes, with each sensor pair being distinctly associated with a motion along or rotation about its respective axis. A null or space is provided between the sensors of each sensor pair for allowing a small amount of movement potential along and about each of the three axes before actuation of a sensor. Each sensor pair having associated return-to-center resiliency and sensor-actuation feedback to be detected by the user upon activation of a sensor. Low profile structuring and sheet supported sensors allow ready low-cost integration into a keyboard and other devices such as a hand-held remote control unit, etc. Preferred structures allow for "pure-separate" interpretation to provide a true 6 DOF controller. The invention offers superior function and feel to the user and also innovative structuring for low-cost manufacture.