United States Patent

Jackson

[15] **3,643,041**

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[54] PUSHBUTTON DIAPHRAGM SWITCH WITH IMPROVED DIMPLE ACTUATOR AND/OR CAPACITANCE-TYPE SWITCH CONTACT STRUCTURE

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[52] **U.S. Cl.**.....**200/5 A,** 200/DIG. 1, 200/159 B

[51] **Int. Cl.**.....**H01h 9/26,** H01h 35/00

[58] **Field of Search**.....200/1 R, 5 A, DIG. 1, 159 B

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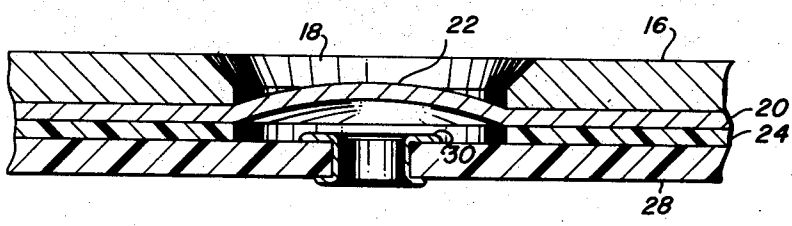
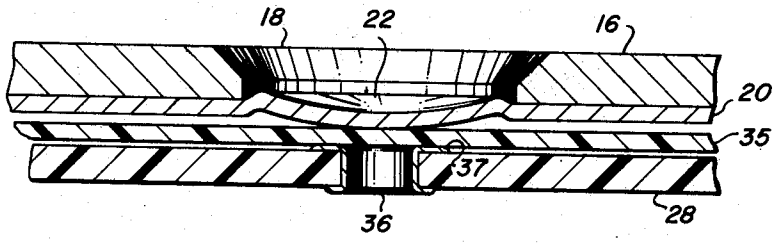
[57] **ABSTRACT**

A faceplate is provided with a plurality of openings therein, each representing a digit to be used in a keyboard; a metal switch plate is positioned immediately beneath the faceplate and includes a plurality of dome-shaped resilient deformable dimples forming keys therein, each registering with and extending into a different one of said openings. An insulating plate, with holes therein registering with the dimples, separates the switch plate from a contact board that includes a plurality of contact buttons, each registering with one of the holes in the insulating plate. The dimples may be depressed by the fingertip of an operator to "snap" into contact with a corresponding contact button and will "snap" back to their original position when fingertip pressure is released.

10 Claims, 5 Drawing Figures





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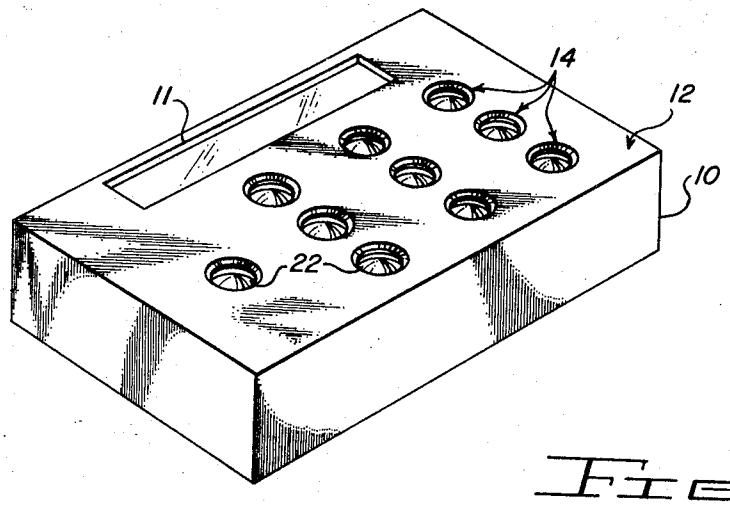

Fig. 1

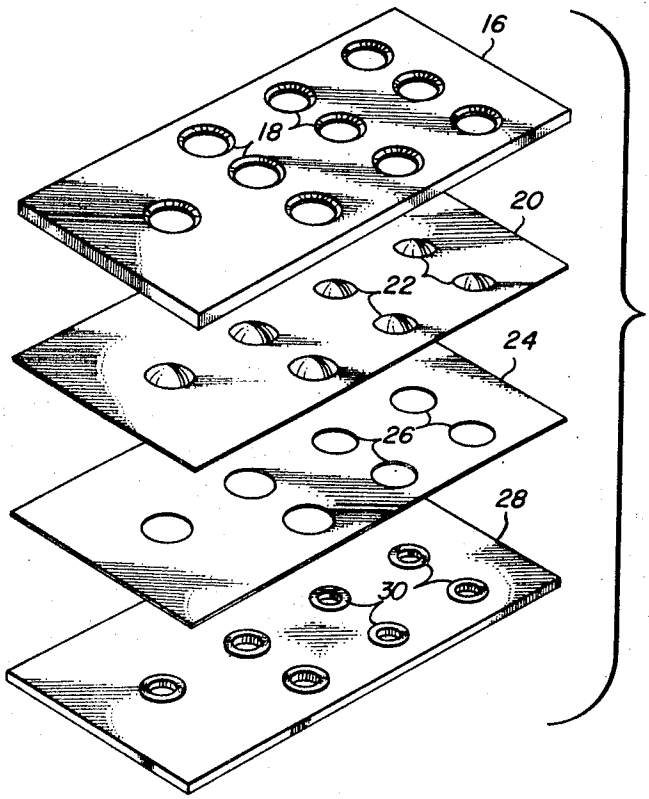

Fig. 2

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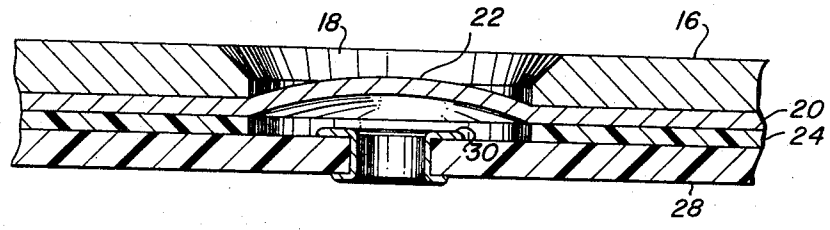

FIG. 3

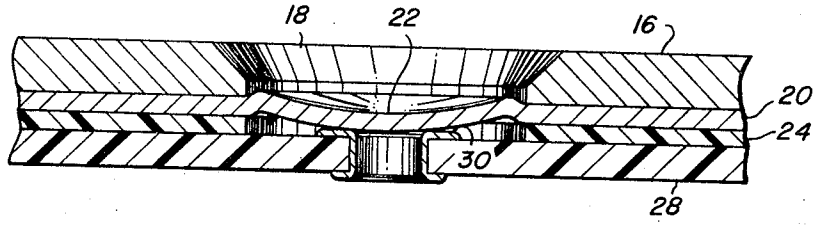

FIG. 4

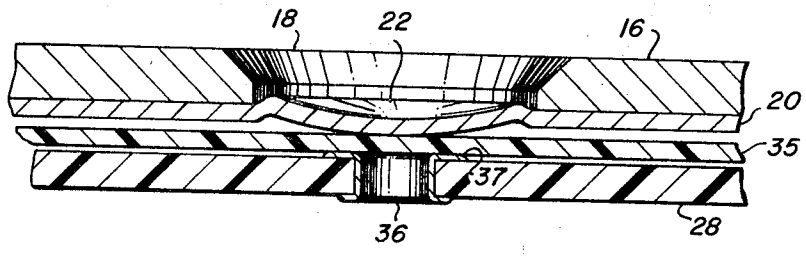

FIG. 5

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PUSHBUTTON DIAPHRAGM SWITCH WITH IMPROVED DIMPLE ACTUATOR AND/OR CAPACITANCE-TYPE SWITCH CONTACT STRUCTURE

The present invention pertains to keyboards, and more particularly, to keyboard switching devices suitable for use in those instances where keyboard size is a design factor.

Miniaturization of electronic components and the introduction of integrated circuitry has enabled the reduction in size and bulk of many electrical devices; however, in numerous applications of electronic technology, there exists the requirement for a mechanical interface between the human operator and the electronic apparatus.

One such application of miniaturization is in the field of calculators wherein the heretofore bulky mechanical and electromechanical operations may now be performed by compact electronic techniques, such as integrated circuitry, etc. The requirement nevertheless exists for a mechanical interface in the form of a keyboard to permit the operator to enter the required information for subsequent calculation. The keyboard therefore becomes a critical element in determining the size of such a device. An attempt to miniaturize a keyboard has previously resulted in the incorporation of undesirable features. For example, it is desirable to incorporate a mechanical sensory feedback signal to the operator to enable the operator to determine by touch whether or not the key of the keyboard has properly been depressed. With larger keyboards and with concomitant larger displacements of mechanical keys, this touch signal is inherent in the "feel" of the keyboard; however, in reducing the size of the keyboard and the length of travel of any key in the keyboard, the sense of touch becomes critical.

It is therefore an object of the present invention to provide a keyboard that is compact.

It is also an object of the present invention to provide a keyboard incorporating a positive mechanical displacement with a minimum of bulk.

It is still another object of the present invention to provide a keyboard that can be constructed in very little space and nevertheless provide a mechanical sensory feedback signal through the fingertip of the operator.

These and other objects of the present invention will become apparent to those skilled in the art as the description thereof proceeds.

The present invention may be described by reference to the accompanying drawings, in which:

FIG. 1 is a perspective view of a calculator incorporating the keyboard of the present invention.

FIG. 2 is an exploded view of a keyboard incorporating the teachings of the present invention.

FIG. 3 is a cross-sectional view of a portion of the keyboard of FIG. 1, showing a single key thereof.

FIG. 4 is a cross-sectional view of the key of FIG. 3, shown in a closed-circuit position.

FIG. 5 is a cross-sectional view illustrating a key of another embodiment of the present invention.

Referring now to FIG. 1, a calculator **10** is schematically illustrated in the form of a small block having a window **11** for viewing an alphanumeric display (not shown). The calculator includes a keyboard generally indicated at **12**, having a plurality of keys **14** arranged in a convenient manner to be depressed by the fingertip of an operator, thus entering the required information into the calculator.

Referring now to FIG. **2**, the keyboard **12** of FIG. **1** is shown in greater detail and in an exploded form. The keyboard includes a metal faceplate **16** having a plurality of openings **18** therein. A metal switch plate **20** is mounted immediately below and in contact with the cover plate **16**. The switchplate **20** is formed of a continuous flat metal sheet having a plurality of dome-shaped resilient deformable dimples **22** therein. The dimples **22** are convex upward and register with and extend into corresponding openings **18**. Immediately below the switchplate **20** an insulating spacer **24** is provided and may be formed of any convenient insulating material such as Mylar having a plurality of holes **26** therein. As may be seen in FIG. **2**, the holes each register with a different one of the dimples **22** of the switchplate **20**. Positioned below the insulating plate **24** and in contact therewith is a contact board **28** that may also be formed of any convenient insulating material, such as found in printed wiring boards. Contact buttons or rivets **30** are secured to the contact board **28** and are positioned in registration with the holes **26**, dimples **22**, and openings **18**. The faceplate **16**, switchplate **20**, insulating plate **24**, and contact board **28** form a "sandwich" which is extremely compact and occupies only a top thin layer of the calculator **10**.

A cross-sectional view of one of the keys of FIGS. **1** and **2** is shown in FIG. **3**. It may be seen by reference to FIG. **3** that the dimple **22** is convex upward and extends into the opening **18**. An electrical circuit (not shown) may be connected between the switchplate **20** and any one of the contact buttons **30**. The circuit selected to be energized would, of course, depend on which of the buttons **30** comes in contact with its corresponding dimple **22**.

The operation of the keyboard of the present invention may be described by reference to FIGS. **3** and **4**, wherein it may be seen in FIG. **3** that no electrical contact exists between the dimple **22** and the button **30**. The operator's fingertip is placed in the opening **18** of the faceplate **16** and contacts the convex surface of the dimple **22**. Downward pressure on the dimple will be resisted until a certain predetermined force is exerted, whereupon the dimple "collapses" with a snap action, resulting in the convex portion of the dimple becoming concave and the dimple contacting the button **30**, as shown in FIG. **4**. This snap action results in a mechanical sensory feedback signal through the fingertip of the operator. The sensation received by the operator is a snap sensation similar to that received when operating a toy clicker device which emits an audible clicking sound when depressed. The action of the dimple while collapsing is a modified overcenter action wherein a force on the convex portion of the dimple beyond a predetermined portion results in the collapse of the dimple but does not cause the dimple to permanently assume a convex shape; rather, immediately upon releasing the dimple, it will snap into its original shape. This snap action provides the operator with a desirable mechanical sensory feedback signal which enables him to determine that the key has properly been depressed.

The switch plate may be formed of a continuous flat metal sheet as mentioned previously; however, it has been found that good results are achieved utilizing a continuous flat plastic sheet having the bottom surface thereof metallized such as by coating with a film of aluminum.

The snap action may be achieved through a variety of switch plate and dimple dimensions. For example, it has been found that suitable action has been achieved through the utilization of a switch plate formed of a continuous flat metal sheet of stainless steel having a thickness of approximately 0.001 inch and with dimples formed therein having approximately ½-inch diameter and a maximum height of approximately 0.03 inch. It has been found that these dimensions provide suitable key sizes for the average operator's fingertips, while providing excellent mechanical sensory feedback signals. Obviously, dimensional variations may be incorporated in the keyboard without departing from the spirit thereof.

The keyboard described above incorporates switches which make or break electrical contact between dimples **22** and corresponding contact buttons **30**; another embodiment of the present invention is shown in FIG. **5**. In FIG. **5**, the faceplate **16**, opening **18**, switchplate **20**, dimple **22**, and contact board **28** are identical to those described above. In the embodiment shown in FIG. **5**, however, the insulating plate **35** is a continuous flat insulating sheet without openings or holes and thus insulates the dimple **22** from the button **36**. Also, the button **36** incorporates a somewhat larger upper surface **37** for reasons to be explained. When the dimple **22** is depressed as shown in FIG. **5**, the capacitance existing between the button **37** and the dimple **22** is substantially greater than when the dimple is in its original position. Therefore, a circuit connected between

the button **36** and the switchplate **20** will incorporate a variable capacitance depending on the position of the dimple **22** with respect to the button **36**. Conventional capacitance change sensed circuitry may be utilized to detect this change in capacitance resulting from the depression of the dimple **22**, thus providing a keyboard operable through an induced change in capacitance at the selected keys.

It may therefore be seen that the keyboard of the present invention utilizes a minimum volume while nevertheless permitting a larger number of keys to be incorporated. In addition, the keyboard provides a mechanical sensory feedback signal through the fingertip of the operator while nevertheless requiring minimal key travel. The "sandwich" arrangement of the plates and spacers automatically isolates the contact buttons **30** from the atmosphere or from contamination through the openings **18** in the faceplate. The snap action of the respective dimples when contacting their corresponding contact buttons results in contact cleaning, thus assuring excellent electrical properties during the life of the keyboard. It will therefore be obvious to those skilled in the art that many modifications may be made in the embodiments chosen for illustration without departing from the spirit of the invention.

I claim:

1. A keyboard for effecting an electrical change upon depression of keys by the fingertips of an operator, comprising: a switchplate, having a plurality of resilient deformable dimples forming keys therein, each having a convex surface; a contact board, positioned adjacent and parallel to said switchplate, having a plurality of electrical contacts, each registering with a different one of said dimples; insulating means electrically insulating said contact board from said switchplate; each of said dimples, when depressed by an operator's fingertip depressing the convex surface thereof, contacting a corresponding one of said contacts, and when released snapping back to its original position.

2. A keyboard for effecting an electrical change upon depression of keys by the fingertips of an operator, comprising: a faceplate including a plurality of openings thereon; a switchplate, positioned parallel to said faceplate, having a plurality of resilient deformable dimples forming keys therein, each having a convex surface registering with and extending into a different one of said openings; a contact board, positioned adjacent and parallel to said switchplate, having a plurality of electrical contacts, each registering with a different one of said dimples; insulating means electrically insulating said contact board from said switchplate; each of said dimples, when depressed by an operator's fingertip depressing the convex surface thereof, contacting a corresponding one of said contacts, and when released snapping back to its original position.

3. A keyboard for effecting an electrical change upon depression of keys by the fingertip of an operator, comprising: a faceplate, including a plurality of openings therein; a metal switchplate, positioned parallel to said faceplate, having a plurality of dome-shaped resilient deformable dimples forming keys therein, each having a convex surface registering with and extending into a different one of said openings; an insulating plate, positioned adjacent to and parallel to said switchplate, having a plurality of holes, each registering with a different one of said dimples; a contact board, positioned adjacent to and parallel to said insulating plate, having a plurality of electrical contacts, each registering with a different one of said holes; each of said dimples, when depressed by an operator's fingertip depressing the convex surface thereof, extending through one of said holes and contacting a corresponding one of said contacts, and when released snapping back to its original position.

4. The combination set forth in claim **2**, wherein each of said keys, when depressed, transmits a mechanical sensory feedback signal in the form of a snap sensation through the fingertip of the operator to indicate that the key has been properly depressed.

5. The combination set forth in claim **2**, wherein said switchplate is a continuous flat metal sheet having a plurality of dome-shaped resilient deformable dimples therein.

6. The combination set forth in claim **2**, wherein said switchplate comprises a continuous sheet of plastic material having a metallized surface thereon, said metallized surface including the concave surfaces of said dimples.

7. A keyboard for effecting an electrical change upon depression of keys by the fingertips of an operator, comprising: a faceplate, including a plurality of openings therein; a switchplate positioned parallel to said faceplate, having a plurality of dome-shaped resilient deformable dimples forming keys therein, each having a convex surface registering with and extending into a different one of said openings; an insulating plate positioned adjacent and parallel to said switchplate; a contact board positioned adjacent and parallel to said insulating plate, having a plurality of electrical contacts, each registering with a different one of said dimples, a predetermined capacitance existing between each of said dimples and the corresponding electrical contact; each of said dimples, when depressed by an operator's fingertip depressing the convex surface thereof, contacting said insulating plate and changing the capacitance between the dimple and corresponding electrical contact.

8. The combination set forth in claim **7**, wherein each of said keys, when depressed, transmit a mechanical sensory feedback signal in the form of a snap sensation through the fingertip of the operator to indicate that the key has been properly depressed.

9. The combination set forth in claim **7**, wherein said switchplate comprises a continuous flat metal sheet having a plurality of dome-shaped resilient deformable dimples therein.

10. The combination set forth in claim **7**, wherein said switchplate comprises a continuous sheet of plastic material having a metallized surface thereon, said metallized surface including the concave surfaces of said dimples.

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