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Suzumura

[11] **3,898,421**

[45] **Aug. 5, 1975**

[54] **PUSH BUTTON SWITCH WITH ELASTIC CONDUCTIVE SHEET**

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[73] Assignee: **Matsushita Electric Industrial Co., Ltd.,** Osaka, Japan

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Sept. 11, 1972	Japan	47-106404
Oct. 20, 1972	Japan	47-121594

[52] **U.S. Cl.** ..... **200/159 B;** 200/241

[51] **Int. Cl.** **H01h 13/52**

[58] **Field of Search** .... 200/159 B, 5 A, 83 N, 83 B, 200/83 P, 241, 243, 168 G, 83 Y, 83 W, 67 DB

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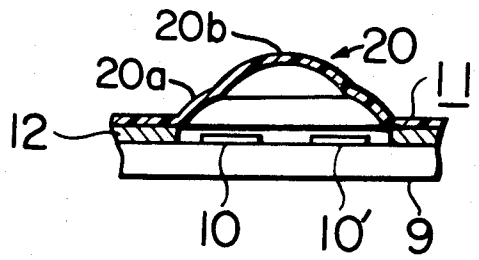
Primary Examiner—Robert K. Schaefer
Assistant Examiner—William J. Smith
Attorney, Agent, or Firm—Stevens, Davis, Miller & Mosher

[57] **ABSTRACT**

There is provided a push button switch using an elastic conductive sheet having a spherical protuberance which is adapted to be deformed by a keytop for electrically connecting fixed electrodes formed on a printed circuit board. Spring means for returning the keytop is not required, so that the construction is simplified. Also, excellent switching action, operability and reliability can be ensured.

5 Claims, 25 Drawing Figures



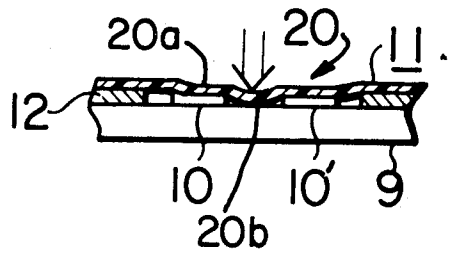


FIG. 1
PRIOR ART

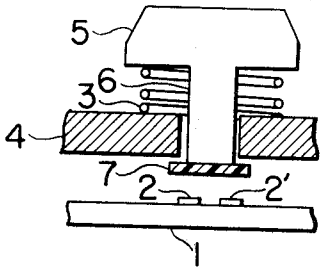


FIG. 2
PRIOR ART

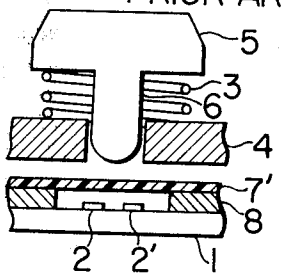


FIG. 4

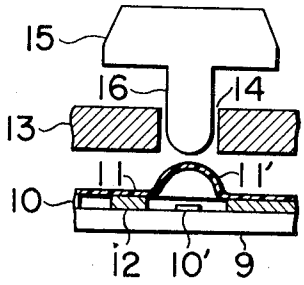


FIG. 5

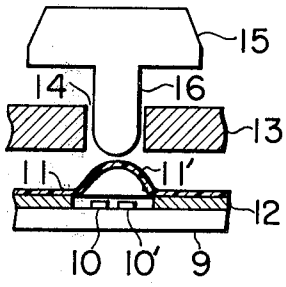


FIG 6a

FIG. 6b

FIG. 3

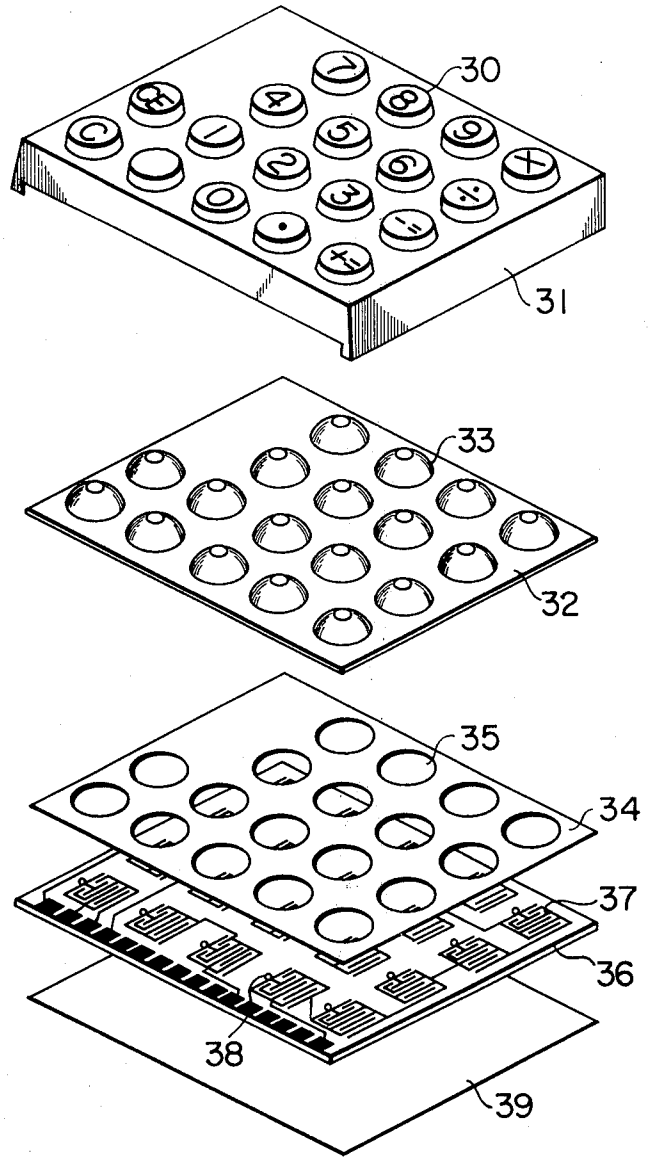


FIG. 7a

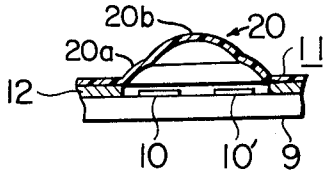


FIG. 7b

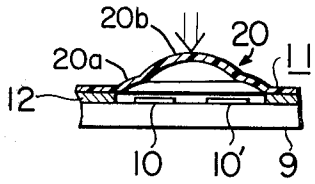


FIG. 7c

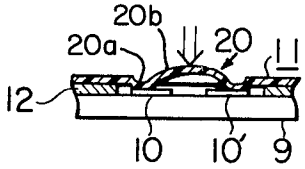


FIG. 7d

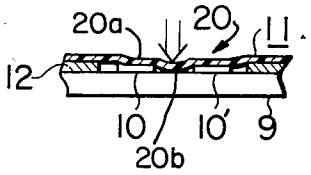


FIG. 8

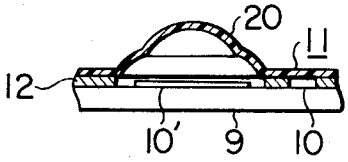


FIG. 9

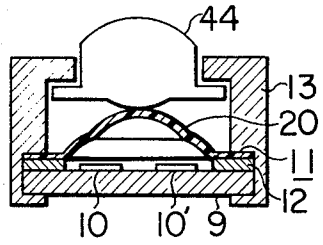


FIG. 10

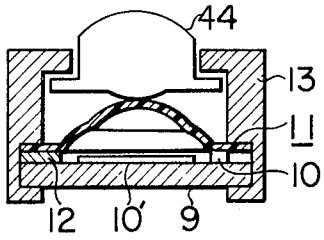


FIG. 11a

FIG. 11b

FIG. 11c

FIG. 12

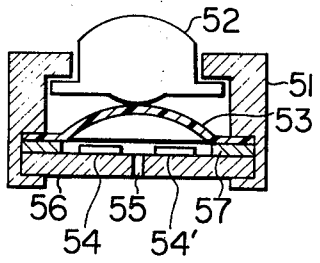


FIG. 13

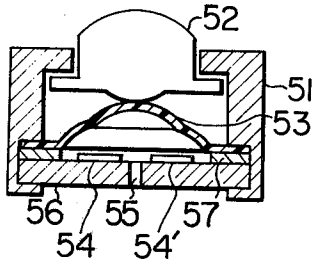


FIG. 14

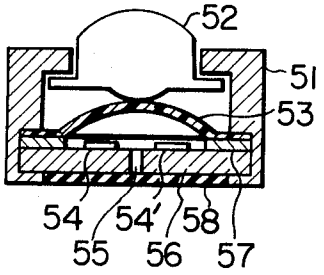


FIG. 15

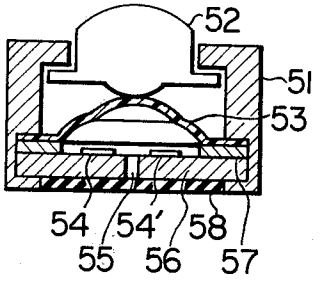


FIG. 16

FIG. 17

FIG. 18

FIG. 19

PUSH BUTTON SWITCH WITH ELASTIC CONDUCTIVE SHEET

This invention relates to push button switches using as elastic conductive sheet, and has as an object providing a push button switch suited particularly for use as a keyboard switch for desk-top electronic calculators.

Other objects, features and advantages of the present invention will be apparent from the following description taken in conjunction with the accompanying drawings, in which:

FIGS. **1** and **2** are sectional views showing prior art push button switches using a conductive plastic sheet;

FIG. **3** is an exploded perspective view of a keyboard switch assembly for desk-top electronic calculators using the push button switch according to the invention;

FIGS. **4** and **5** are sectional views showing embodiments of the push button switch according to the invention;

FIGS. **6***a* and **6***b* are sectional views showing different forms of the spherical protuberance incorporated in the push button switch according to the invention;

FIGS. **7***a* to **7***d* show the way in which the spherical protuberance of the push button switch according to the invention is deformed with pressure;

FIG. **8** is a sectional view showing a further example of the push button switch according to the invention;

FIGS. **9** and **10** are sectional views showing other embodiments of the push button switch according to the invention;

FIGS. **11***a* to **11***c* show examples of the spherical protuberance having a nodal character;

FIGS. **12** to **15** are sectional views showing still further embodiments of the push button switch according to the invention;

FIG. **16** is a view showing a conductor pattern on the printed circuit board of a prior art push button switch; and

FIGS. **17** to **19** are views showing electrode patterns on the printed circuit board of the push button switch according to the invention.

The prior art switch in which metal contacts are made and broken is prone to the phenomenon of chattering at the time the contacts are made. Also, if the contact pressure when the contacts are made is unnecessarily high, wear of the contact area becomes high, rendering the contact state unstable. This is of course undesirable from the standpoint of reliability, durability and safety to the switch. Heretofore, various types of switches have been proposed for overcoming the above drawbacks.

For example, push button switches in which the switching action is obtained by bringing a conductive plastic film into contact with electrodes printed on a printed circuit board and normally held underneath the conductive plastic film at a predetermined distance therefrom are roughly classed into two types as shown in FIGS. **1** and **2**.

The switch of the type shown in FIG. **1** comprises a printed circuit board **1** having two electrodes **2** and **2'** printed thereon, a return spring member such as a coil spring **3**, a keytop **5** held in a frame **4** and having a downward integral extension **6**, and a conductive plastic sheet piece **7** provided at the lower end of the extension **6** and having an area capable of covering both the electrodes **2** and **2'**. The other type of switch shown in

FIG. **2** has a construction consisting of a printed circuit board **1** having two electrodes **2** and **2'** printed thereon, a return spring member such as a coil spring **3**, a keytop **5** held in a frame **4** and having a downward integral extension **6** and a conductive plastic sheet **7'** supported on a spacer intervening between printed circuit board **1** and plastic sheet **7'** to hold the plastic sheet above and at a slight distance from the electrodes **2** and **2'**.

The switches of both of these types are actuated or closed when the electrodes **2** and **2'** are contacted by the conductive plastic sheet piece **7** or plastic sheet **7'** due to vertical displacement of the plastic film piece toward the electrodes **2** and **2'** on the printed circuit board **1** caused by depressing the keytop **5**.

In the switches of the above constructions, however, the elasticity of the conductive plastic sheet piece **7** or plastic sheet **7'** constituting an element of the switch is not fully utilized. Also, since the plastic sheet piece is displaced in the vertical direction with respect to the electrodes, the closing of the switch is achieved only at the end of the downward stroke of the keytop. In other words, there is provided no play for any extra movement of the keytop after the switch is turned on, and the switch will not be actuated until the keytop is depressed through the full stroke. Therefore, the keytop **5** is subject to excessive depressing force, so that the wear of the contact area is spoiled. Further, since the keytop return spring **3** is used, the spring and the conductive plastic film piece are likely to resonate due to the elasticity of the spring and the complex elasticity of the conductive plastic, so that the possibility of occurrence of chattering is increased. This problem has been fatal in the prior art push button switch, and this type of chattering has direct bearing upon the user's power or skill to operate the keytop and is liable to lead to malfunctioning of the keyboard switch of the desk-top electronic calculators and push botton telephone sets where chattering is particularly undesirable, thus greatly degrading the reliability and durability of these machines.

An object of the invention is to provide a push button switch having a construction effectively utilizing the elasticity of an elastic sheet of a conductive material such as a conductive rubber sheet and conductive plastic sheet for returning the keytop due to the elasticity of the elastic sheet.

Another object of the invention is to prevent chattering by an arrangement wherein the switch is closed at an intermediate point of the full stroke of the keytop.

A further object of the invention is to provide a push button switch which can be reliably closed by lightly depressing the keytop.

A still further object of the invention is to provide simplified construction and improved reliability of the switch by using a conductive plastic sheet.

The push button switch according to the invention will now be described in connection with some embodiments thereof.

FIG. **3** shows a keyboard switch assembly for desk-top electronic calculators using the push button switch according to the invention. In the Figure, reference numeral **30** designates a keytop supported in a frame **31** such that it can be moved vertically. Numeral **32** designates an elastic conductive sheet formed with a plurality of spherical protuberances **33** each formed at a position corresponding to the associated keytop **30**. Numeral **34** designates an insulating sheet formed with

holes **35** each corresponding in position to the associated spherical protuberance **33.** Numeral **36** designates a printed circuit board having conductor patterns **37** printed thereon. It is also formed with small holes **38** each for each switch. Numeral **39** designates a dust filter.

FIGS. **4** and **5** show embodiments of the push button switch according to the invention. In these Figures, like reference numerals refer to corresponding parts.

The embodiment of FIG. **4** comprises a printed circuit board **9** having electrodes **10** and **10'** formed thereon. Held over the printed circuit board **9** and supported on a spacer **12** having a diaphragm structure is a conductive plastic sheet having a spherical protuberance **11'** extending directly above the electrode **10'**. The other electrode **10** is in contact with the conductive plastic sheet **11.** Numeral **13** designates a frame having a hole **14,** and numeral **15** designates a keytop having an integral downward extension **16.** The keytop **15** is mounted in the hole **14** of the frame **13** such that it can be moved vertically.

In operation, by downwardly depressing the keytop **15** the lower end of the extension **16** of the keytop **15** pushes and deforms the spherical protuberance **11'** of the conductive plastic sheet **11** to bring the protuberance **11'** into contact with the electrode **10'**, thus electrically connecting the electrodes **10** and **10'**. If the conductive plastic sheet **11** formed with the spherical protuberance **11'** has elasticity, the spherical protuberance **11'** will flex in a quick action. More particularly, when pressure is applied to the keytop **15,** it will not flex until a certain predetermined pressure is reached and will undergo sudden flexural deformation as soon as this pressure value is exceeded. When the pressure applied to the keytop **15** is removed, the spherical protuberance is quickly restored to the initial state and separated from the fixed electrode **10'**, thus opening the associated electric circuit. In this way, the electric circuit is closed and opened. Since this is down in a quick action, reliable operation can be ensured. Also, the coil spring for returning the keytop used in the prior art can be omitted, which is a great advantage in view of the cost.

In the embodiment of FIG. **5,** which also uses a conductive plastic sheet having a spherical protuberance, the conductive plastic sheet **11** is normally in contact with neither electrode **10** or **10'**, and it is brought into contact with both electrodes **10** and **10'** on the printed circuit board **9** normally extending below it for closing the switch. Otherwise, the operation and effects are the same as in the preceding embodiment of FIG. **4.**

The extent of the quick action and the returnability of the keytop may be suitably preset by appropriately selecting the hardness and thickness of the conductive plastic sheet and the shape and dimensions of the spherical protuberance.

FIGS. *6a* and *6b* show other possible shapes of the spherical protuberance, and these and other shapes may be appropriately selected to match the design values of the push button switch depressing pressure, stroke and so forth.

FIGS. *7a* to *7d* show transforming states of movements according to an embodiment of the invention. This switch according to the invention comprises a support consisting of a printed circuit board **9** having electrodes **10** and **10'** formed thereon by means of the printed circuit technique, an elastic conductive plastic sheet **11** having a spherical protuberance or dimple **20** having a flexural node for two-step deformation and a spacer **12** having a diaphragm structure for insulating the sheet **11** from the printed circuit on the printed circuit board. In this embodiment, an annular shoulder **20***a* on the spherical protuberance or dimple **20** of the conductive plastic sheet **11** is brought into contact with the electrodes **10** and **10'** due to its flexing for closing the associated electric circuit.

FIG. *7a* shows the switch in its "off" state without any pressure exerted on the spherical protuberance **20.** When pressure is exerted on the spherical protuberance **20** for turning on the switch, the conductive plastic sheet **11** flexes about the flexural node of the spherical protuberance **20** as shown in FIG. *7b*. Then, as the first step in the deforming action the flexural node shoulder **20**a are brought into contact with the board **9** as shown in FIG. *7c*. As this instant, the flexural node is brought into contact with the electrodes **10** and **10'** on the board **9** to turn on the switch. Subsequently, the conductive plastic sheet **11** can undergo the second step deformation wherein the central portion **20***b* of the dimple **20** is pressed between electrodes **10** and **10'** as shown in FIG. *7d*. In this way, there is provided a so-called trouble after the closure of the switch.

If the conductive plastic sheet **11** formed with the spherical protuberance **20** has elasticity, the spherical protuberance **20** will flex in quick action. More particularly, when pressure is applied to it, it will not flex until a certain predetermined pressure is reached and will undergo sudden flexural deformation as soon as this pressure level is exceeded.

When the pressure applied is removed, the spherical protuberance **20** is quickly restored to its initial state and separated from the electrodes **10** and **10'**, thus opening the associated electric circuit. In this way, the electric circuit is closed and opened. Since this is done in quick actions, reliable operation can be ensured. Also, it is possible to suitably preset a point at which the switching action takes place (FIG. *7c*) during the total displacement from the state of FIG. *7a* to the state of FIG. *7d* (corresponding to the full stroke of the push button switch) so as to provide for the so-called trouble for the displacement from the state of FIG. *7c* to the state of FIG. *7d*. By doing so, an excellent sense of operation may be obtained. Further, since the spherical protuberance **20** can provide a large restoring force, the coil spring for returning the keytop in the prior art can be omitted, which is a great advantage in view of the cost.

FIG. **8** shows a modification of the preceding embodiment. In this modification, the electrode **10** and conductive plastic sheet **11** are always in contact with each other, and only when turning on the switch the flexural node portion of the spherical protuberance **20** of the conductive plastic sheet **11** is brought into contact with the other electrode **10'**.

FIGS. **9** and **10** show embodiments of the push button switch using the afore-mentioned switching mechanism. In these embodiments, the keytop **44** made of an insulating material is mounted in a hole formed in the top wall of a switch frame **13** such that it can be moved vertically, and the afore-mentioned switching mechanism is provided below the keytop **44.** In the embodiment of FIG. **9,** the switching mechanism consists of a printed circuit board **9** having electrodes **10** and **10'** provided with leads, a conductive plastic sheet **11** and

a spacer **12** for insulating the conductive plastic sheet **11** when the switch is off. In the embodiment of FIG. **10**, the electrode **10** is always in contact with the conductive plastic sheet **11**, and only when turning on the switch the flexural node portion of the spherical protuberance **20** of the conductive plastic sheet **11** is brought into contact with the other electrode **10'**. In the operation of these embodiments, with the downward movement of the keytop **44** of the conductive plastic sheet **11** is flexed and brought into contact with the electrodes **10** and **10'** (or only the electrode **10**) at the time of the first step deforming action, with the second step deforming action reserved for the so-called trouble after the closure of the switch. In this way, the closing and opening of the associated electric circuit are effected.

The extent of the quick action and the returnability of the keytop may be suitably preset by appropriately selecting the hardness and thickness of the conductive plastic sheet and the shape and dimensions of the flexural node of the spherical protuberance.

FIGS. **11a** to **11c** show possible shapes of the spherical protuberance having a flexural node for two-step deformation, and these and other shapes may be appropriately selected to match the design values of the push button switch depressing pressure, stroke and so forth. Also, where a plurality of push button switches are assembled into a keyboard switch assembly for desktop electronic calculators, push botton telephone sets and so forth, the productivity may be improved by using a single sheet formed with a plurality of spherical protuberances at a suitable pitch as the conductive plastic sheet **11**.

FIGS. **12** and **13** show further embodiments of the push button switch according to the invention. Either of these embodiments comprises a switch frame **51**, a keytop **52** of an insulating material mounted for vertical movement in a hole formed in the top wall of the frame **51**, a conductive plastic sheet **53** disposed below the keytop **52** and having a spherical protuberance, electrodes **54** and **54'** facing the spherical protuberance and formed on a board **56** formed with a small hole **55** and a spacer **57** of a diaphragm structure provided for taking out leads from the electrodes **54** and **54'** and insulating the plastic sheet **53**.

In operation, when the keytop **52** is downwardly depressed with pressure applied thereto, the spherical protuberance of the conductive plastic sheet **53** undergoes flexural deformation and is brought into contact with the electrodes **54** and **54'** to close the associated electric circuit. When the applied pressure is removed the electric circuit is opened due to the effect of the small hole **55** formed in the board **56** and the elastic restoring force of the conductive plastic sheet **53**. In this way, the electric circuit is closed and opened.

In the embodiment of FIG. **12**, the conductive plastic sheet **53** is adapted to undergo single step deformation, with the switch closed at the end of the full stroke, while in the embodiment of FIG. **13** two-step deformation of the conductive plastic sheet is provided to provide for a so-called trouble after the closure of the switch. In both these embodiments, the function and effects of the small hole **55** formed in the board **56** are the same.

FIGS. **14** and **15** show still further embodiments of the push button switch according to the invention. Either of these embodiments comprises a switch frame, a keytop of an insulating material mounted for vertical movement in a hole formed in the top wall of the frame **51**, a conductive plastic sheet **53** disposed below the keytop **52** and having a spherical protuberance, electrodes **54** and **54'** facing the spherical protuberance and formed on a board **56** formed with a small hole **55**, a spacer **57** of a diaphragm structure provided for taking out leads from the electrodes **54** and **54'** and insulating the plastic sheet **53** and a fibrin cloth-like insulator **58** serving as a filter.

In operation, when the keytop **52** is downwardly depressed with pressure applied thereto, the spherical protuberance of the conductive plastic sheet **53** undergoes flexural deformation and is brought into contact with the electrodes **54** and **54'** to close the associated electric circuit. When the applied pressure is removed, the electric circuit is opened due to the effect of the small hole **55** formed in the board **56** and the elastic restoring force of the conductive plastic sheet **53**. In this way, the electric circuit is closed and opened.

In the embodiment of FIG. **14** the conductive plastic sheet **53** is adapted to undergo single step deformation, with the switch closed at the end of the full stroke, while in the embodiment of FIG. **15** two-step deformation of the conductive plastic sheet is provided to provide for a so-called trouble after the closure of the switch. In both these embodiments, the function and effects of the small hole **55** formed in the board **56** and the filter **58** are the same.

For the fibrin cloth-like insulator **58** which serves as a filter, a porous or net-like material which permits the flow of air but does not transmit the dust in the air may be used. While felt is the best material, formed plastic such as urethane foam having thin continuous pores may also be effectively used. Also, it may extend over the entire back area of the board **56** or only for the portion adjacent the small hole **55**.

As has been described, according to the invention with the provision of the spherical protuberance in the conductive plastic sheet and the small hole in the printed circuit board the resonance and bounce phenomena can be eliminated, and also the chattering can be minimized. Further, reliable return action can be ensured. Furthermore, with the provision of the filter means contact failure due to collection of dust can be prevented. Thus, it is possible to provide a push button switch having excellent reliability and stability.

FIGS. **16** to **19** show conductor patterns to be formed on the printed circuit board. FIG. **16** shows a prior art pattern. With such a simple pattern consisting of two separate rectangles it is likely that a steady and stable contact state is not obtained depending upon the shape and structure of the conductive material brought into contact with the electrodes, giving rise to chattering phenomenon at the time of contact. FIGS. **17** to **19** show conductor patterns which can prevent such chattering phenomenon. With combinations of comb-like patterns of the two electrodes printed on the board, reliable and stable contact of these electrodes with the conductive plastic material may be ensured so that it is possible to provide a push button switch of high reliability.

What we claim is:

1. A push button switch comprising support means; a pair of fixed spaced electrodes located on said support means; and an elastic conductive sheet having a dimple positioned adjacent said electrodes and spaced

therefrom by a predetermined distance, said dimple including a central portion and an annular shoulder separated from said central portion by a flexural node, said dimple being deformable with a double snap action when depressed by a force exerted on the central portion thereof, the first snap action of said dimple forcing said annular shoulder into contact with said pair of fixed electrodes thereby making electrical contact therebetween, and the following snap action forcing the central portion of said dimple between said electrodes.

2. A push button switch comprising a printed circuit board; spaced fixed electrode means printed on said printed circuit board; an elastic conductive sheet having a dimple positioned adjacent said electrodes and spaced therefrom by a predetermined distance, said dimple including a central portion and an annular shoulder separated from said central portion by a flexural node, said dimple being deformable with a double snap action when depressed by a force exerted on the

central portion thereof; and a keytop slidably supported above said dimple for depressing said dimple, the first snap action of said dimple forcing said annular shoulder into contact with said pair of fixed electrodes thereby making electrical contact therebetween, and the following snap action forcing the central portion of said dimple between said electrodes.

3. The push button switch according to claim **2**, which further comprises an insulating member having a hole therein in the position corresponding to said dimple, said insulating member being disposed between said conductive sheet and said printed circuit board.

4. The push button switch according to claim **2**, wherein said printed circuit board has a small hole for the escape of air.

5. The push button switch according to claim **2**, which further comprises a fibrin filter provided on the underside of said printed circuit board.

* * * * *