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(54) KEYBOARD ASSEMBLIES

(71) We, CHOMERICS, INC., a corporation organised under the laws of the State of Delaware, of 77 Dragon Court, Woburn, Massachusetts 01801, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention is concerned with keyboard assemblies.

Within the last few years the personal calculator market has mushroomed with the result that many manufacturers have entered the business. With numerous manufacturers competing for the same market, the price of calculators has begun to decrease rapidly and calculator manufacturers have looked for ways to cut their manufacturing and component costs.

One of the components for which a cost reduction has been sought is the keyboard.

A keyboard assembly according to the present invention comprises an electrically conductive contact means on a support, an electrically conductive contactor positioned in register with but normally out of contact with the contact means, and an insulating sheet of plastics material having a plurality of protrusions formed therein, the sheet being so positioned with respect to the contactor and contact means that the protrusions normally point away from the contact means, each protrusion being adapted, when depressed, to move by snap action to a position in which it urges the contactor against the contact means, a depressed protrusion returning to its initial position after release of pressure.

The invention permits the use of a common sheet, constituting the operating surface of the keyboard assembly, for a number of contact-contactor combinations, the sheet being formed with a respective protrusion

covering and extending away from each of the contact-contactor combinations. The sheet may be formed from a resilient and flexible plastics material and each protrusion may consist of a cylindrical pedestal capped by a convex surface. Numbers, letters or symbols may be printed or stuck on to the curved surfaces.

In one form of keyboard assembly embodying the invention, each protrusion is formed with a flexible conductor on its inner side, this conductor constituting the electrical contactor.

To the user, the protrusions feel like snap-acting keys when depressed, although they are many times less costly to manufacture than the conventional snap-acting keys. If desired, a key or button may be arranged above each protrusion, the keys or buttons being housed in a common frame. Preferably, a layer having an aperture for each protrusion is provided under the above-mentioned sheet, the protrusion extending into and passing through the said apertured layer when depressed. The apertured layer provides space for the development of the snap action of the protrusion.

In order that the invention may be better understood, several examples of keyboard assemblies embodying the invention will now be described with reference to the accompanying drawings, in which:—

Figure 1 is a top view of a keyboard embodying the invention with parts broken away;

Figure 2 is a top view illustrating one sheet of the keyboard of Figure 1, formed with snap-action protrusions;

Figure 3 is a top view of an apertured separator sheet of the keyboard of Figure 1;

Figure 4 is a sectional view taken along line 4-4 in Figure 2;

Figure 5 is a sectional view taken along line 5-5 in Figure 1, illustrating the moving parts of one section of the keyboard before

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operation;

Figure 6 is a sectional view of the keyboard illustrating the moving parts of one section of the keyboard after operation;

5 Figure 7 illustrates in a sectional view taken similarly to Figure 5 a second embodiment of the keyboard;

10 Figure 8 illustrates in a sectional view taken similarly to Figure 5 a third embodiment of the keyboard;

Figure 9 illustrates in a bottom view the contactor of the keyboard of Figure 8;

Figure 10 is a sectional view taken along line 10-10 of Figure 9;

15 Figure 11 illustrates in a bottom view the sheet with protrusions supporting a conductive layer;

Figure 12 is a sectional view taken along line 12-12 of Figure 11;

20 Figure 13 is a sectional view taken similarly to Figure 5 illustrating the contactor and sheet shown in Figures 11 and 12;

Figure 14 is a bottom view of the sheet with protrusions covered by an electrically conductive layer;

Figure 15 is a sectional view taken along line 15-15 of Figure 14;

30 Figure 16 is a sectional view similar to Figure 5 illustrating the coated sheet of Figures 14 and 15 in the keyboard;

Figure 17 is a bottom view of the sheet with protrusions covered by a layer constituting a circuit pattern for making contact with contact elements of a circuit board;

35 Figure 18 is a sectional view taken along line 18-18 of Figure 17;

Figure 19 illustrates in a sectional view a modified keyboard using a button to depress the protrusions of the sheet;

40 Figures 20 and 21 illustrate in a top and bottom view an apparatus suitable for forming the protrusions in the sheet of the Figures and Figure 22 illustrates the protrusion being formed in the plastic sheet; and

45 Figure 23 illustrates in a sectional view similar to Figure 5, a keyboard constructed of a sheet having protrusions without pedestals.

The keyboard shown in Figures 1-6 has 50 frame 30 of a plastics material, e.g. of polystyrene, polypropylene or other high impact plastics material.

The frame is open at the bottom and has an upper surface consisting of cross-members defining twelve windows or openings 31. Rods 32 extend downwardly from the junctions of the cross-members. Enlargements 32a are formed by heat at the base of rods 32 as shown in Figures 5 and 6 to hold 60 together the key board layers to be described. Alternatively the rods may be threaded and nuts may be used to do likewise.

Positioned below the frame top is a layer 35 preferably of a flexible and resilient 65 plastics material having twelve normally

upwardly convex portions 35a each capping a pedestal 35b which is preferably cylindrically shaped although obviously its shape can vary somewhat so long as its side walls can easily spread outwardly as the portions 35a 70 snap through their centre positions (see Figure 6).

The plastics layer 35 may be of thermoplastic or thermosetting flexible and resilient plastics materials, such as polyester, e.g., 75 "Mylar" (Registered Trade Mark), polypropylene, polyethylene, silicone rubbers and polyurethane.

Positioned below the snappable layer in Figures 1-6 is a snap-through layer 36 of 80 insulator material, such as Mylar, having for each convex portion 35a a window or hole 36a of about the same size as base of the pedestal 35b.

It should be understood that the snap-through layer 36 is not essential but it is preferred to include it to provide the user with a better tactile sensation of a snap action; it gives the convex portion 35a enough room to fully invert. 85 90

Below the snap-through layer is an elastomeric conductive plastics layer 37, for example of silicone rubber filled with conductive particles (e.g., silver) as shown in 95 U.S. Patent 3,721,778.

Other well known conductive particles such as carbon, gold, or composites thereof may be used, as is well known in the art.

Positioned below the conductive plastics layer 37 is separator layer 38 of insulator 100 material (e.g. polyethylene) having the same configuration as the layer 36 in Figure 3 and also having holes or windows 38a into which the elastomeric conductive layer 37 may be forced. 105

At 40 there is shown a typical circuit board e.g., of "Bakelite" (Registered Trade Mark) having a conductive pattern 39 supported thereby. The conductive pattern may be etched copper or a conductive ink. 110

In the portion of the keyboard shown in Figure 5 connecting pins 41 and 42 make electrical contact with the conductive plastics layer 37 and with the circuit pattern 39. 115

In Figure 6 the normally convex portion 35a has been pressed and has been forced to snap through its centre position and in turn has forced the conductive plastic layers 37 through the separator 38 and into contact with one or more elements or pathways of the circuit pattern 39. Various circuit patterns are shown in U.S. Patent Specifications Nos. 3,705,276 and 3,721,778. 120

Upon release, the portion 35a and the pedestal 35b return to the unflexed position shown in Figure 5, the electrically conductive contactor or conductive plastic layer 37 also returning as shown. 125

Numbers or other indicia may be applied to the portions 35a by printing techniques 130

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well known in the art or paste-on numbers may be applied thereto. Thus the members 35a look like keys to the user. In practice it has been found that the layer 35 may comprise a 5 mil sheet of Mylar with a pedestal height t_p of 10 mils and a curved portion height of 21 mils, the pedestal bottom having a diameter of about 3/8 inch. The curved portion is a portion of a sphere having a 700 mil radius.

In Figure 7 there is shown an alternative embodiment in which a composite contactor is formed of an elastomeric non-electrically conductive layer 50 and a thin flexible conductive layer 51 such as of a polyamide filled or loaded with conductive particles.

The elastomeric layer may be rubber such as silicone or nitrile, and the flexible conductive layer may be of a polyamide adhesive, e.g. "Versalon" (Registered Trade Mark) 1140, manufactured by General Electric or polyester, e.g. Mylar, filled with silver particles in the range from 20 to 40 volume per cent. The thickness of the elastomeric layer may vary between 5 and 200 mils, a thickness of about 20 mils being most convenient. The flexible conductive pathways 61 and elements of the circuit pattern 39 supported by the circuit board 40. The conductive pattern 61 is supported on the underside of an elastomeric layer 60. The pattern 61 may be sprayed on through a stencil.

The flexible conductive plastics material used for the layer 61 may be the same as the material used for the layer 51 of Figure 7 and the elastomeric layer is also of the same material as layer 50.

Figures 11-13 illustrate yet another embodiment of the invention. In this embodiment as well as the embodiments shown in Figures 14-18, the elastomeric or flexible layers (conductive or non-conductive) as shown in Figures 1-10 are not used.

In Figures 11-13 a thin layer of flexible electrically conductive plastics material 70 adheres to the underside of the convex portions 35a. The flexible conductive plastics material may comprise an epoxy resin e.g. Nazdar Co. BE-170 epoxy; or a polyester, e.g. General Formulation, Div. of General Research Inc. No. 140-1303. In addition adhesives may also be used to attach the layer 70 to the layer 35.

The layer 70 is filled with electrically conductive particles such as silver, gold or carbon, in a volume proportion of between 10 and 80 per cent, 20 to 40 volume per cent being preferred.

The thickness of the layer 70 is preferably 5 microns to 1 mil, 5 microns to 12 microns being preferred. The layer 70 preferably has a volume resistivity of less than 10 ohm cm, more preferably below 1 ohm cm, and most

preferably below .5 ohm cm. The silver particles may be of "Silflake 135".

The flexible conductive plastics layer 70 may comprise other materials, such as polycarbonates (e.g. "Lexan", Registered Trade Mark) epoxy (e.g. Corvel) polyacetate, polystyrene modified or unmodified by a plasticizer to obtain the desired flexibility to permit it to flex with the convex portions 35a and the pedestals 35b.

A suitable formulation for the conductive layer 70 is a mixture of 20 parts by weight of the above-mentioned BE-170 epoxy, and 80 parts by weight of Silflake 135. The formulation is then preferably applied to the layer 35 before forming the protrusions. The layer 70 may be applied to the layer 35 by knife-coating, silkscreening or spraying through a mesh or stencil. Thereafter the layer 70 is cured in an oven as is conventional in the art. The convex portions 35a are now formed. Alternatively, the layer 70 may be applied after the protrusions 35a are formed. Conventional organic solvents, e.g. solvents such as NAZDARS 70-182 Retarder Thinner may be added if desired to permit easy application of the layer 70.

In Figure 13, the separator layer 38 is omitted and the conductive pattern 39 is separated into isolated elements 39a and 39b, contact pins 42a and 42b being coupled to them as shown. Electrical contact is made between the layers 39a and 39b when layer 70 makes contact with both after being depressed.

Figures 14-16 illustrate a further modification in which a layer 80 of flexible conductive plastics material of the same composition and thickness as layer 70 is supported by and adheres to the layer 35. Depression of the convex portion 35a again causes contact with the conductive circuit pattern 39 supported by the board 40. A pin 81 makes electrical contact with the layer 80.

Figures 17 and 18 illustrate still another embodiment wherein a flexible circuit pattern 85 of conductive plastics material is supported by and adheres to the plastic layer 35. A pin similar to the pin 81 of Figure 16 makes electrical contact with a portion of the circuit pattern 85. The configuration of Figures 17 and 18 provides advantages in savings of material. The material 85 is again the same as the flexible material 70 in composition and thickness.

Figure 19 illustrates a device generally similar to that of Figure 1 but using a button 91 supported in a modified frame 90 for depressing the convex portion 35a. In this configuration, the button is merely the extension of a user's finger. Obviously the button and modified frame may be used in any of the other forms described.

Dies 95 and 96, shown in Figures 20-22, may be used to form the flexible layer 35

with the pedestals 35b and the convex portions 35a. In this configuration shaped rods 95a in die 95 mate with cavities 96a in die 96.

- 5 The plastics material 35 is placed between the metal dies (see Figure 22) and pressure and heat is applied for a predetermined period to form the protrusions. In practice it has been found that with a Mylar layer 35
10 of a 5 mil thickness, a temperature of about 210°F with 3000 lbs. pressure for 15 seconds is adequate to form a pedestal with a bottom opening of 3/8" and the convex portion.

- In Figure 23 there is shown a device
15 similar to that shown in Figure 5 except that in this case the sheet 35 is provided with protrusions which consist only of the convex portions 35a, i.e., there are no pedestals 35b. In this case the snap-through layer 36 is
20 preferably made thicker to compensate for the lack of a pedestal. Although this configuration is usable, the protrusions with a pedestal 35b are much preferred because they give a better key-like "feel" under
25 depression. The modifications shown in Figures 7-19 may also be included in the structure of Figure 23.

WHAT WE CLAIM IS:—

- 30 1. A keyboard assembly comprising an electrically conductive contact means on a support, an electrically conductive contactor positioned in register with but normally out of contact with the contact means, and an
35 insulating sheet of plastics material having a plurality of protrusions formed therein, the sheet being so positioned with respect to the contactor and contact means that the protrusions normally point away from the contact
40 means, each protrusion being adapted, when depressed, to move by snap action to a position in which it urges the contactor against the contact means, a depressed protrusion returning to its initial position after release
45 of pressure.

2. A keyboard assembly having an electrically conductive contact means on a support, an insulating sheet of plastics material
50 formed with protrusions which normally point away from the support and a circuit pattern arranged on the side of the sheet facing towards the said support and having parts registering with the said protrusions
55 and constituting contactors, each protrusion being adapted, when depressed, to move by snap action into a position in which it urges the corresponding contactor against the conductive contact means, a depressed protrusion returning to its initial position after
60 release of pressure.

3. A keyboard assembly according to claim 1, in which between the said sheet and
65 the contactor there is a layer formed with a

plurality of holes in register with the said protrusions.

4. A keyboard assembly according to claim 1, 2 or 3, in which between each contactor and the contact means there is inserted
70 a separating layer having a plurality of holes in register with the said protrusions, through which holes the contactor and the contact means can be brought together. 75

5. A keyboard assembly according to claim 1, 2, 3 or 4, in which each protrusion has a curved top surface. 80

6. A keyboard assembly according to claim 5, in which indicia are provided on the curved top portions of the protrusions.

7. A keyboard assembly according to claim 5 or 6, in which each protrusion comprises a pedestal, the curved top surface of the protrusion being connected to the top of the pedestal. 85 90

8. A keyboard assembly according to claim 7, in which the pedestal is of cylindrical shape.

9. A keyboard assembly according to claim 7 or 8, in which the height of the pedestal is less than the height of the said curved portion of the protrusion. 95

10. A keyboard assembly according to any one of the preceding claims, further comprising a button assembly for depressing the protrusions, a separate button being associated with each protrusion. 100 105

11. A keyboard assembly according to any one of the preceding claims, in which the contactor comprises an electrically conductive plastics material. 110

12. A keyboard assembly according to claim 1, in which the inner face of each of the protrusions has a flexible electrically conductive layer adhering thereto and constituting the contactor. 115

13. A keyboard assembly according to claim 12, in which the flexible conductive layer extends over the entire underside of the sheet. 120

14. A keyboard assembly according to claim 1, in which a circuit pattern adheres to the underside of the plastics sheet, portions of the circuit pattern acting as contactors arranged on the undersurfaces of the said protrusions. 125

15. A keyboard assembly according to any one of the preceding claims, in which the 130

with the pedestals 35b and the convex portions 35a. In this configuration shaped rods 95a in die 95 mate with cavities 96a in die 96.

5 The plastics material 35 is placed between the metal dies (see Figure 22) and pressure and heat is applied for a predetermined period to form the protrusions. In practice it has been found that with a Mylar layer 35 of a 5 mil thickness, a temperature of about 210°F with 3000 lbs. pressure for 15 seconds is adequate to form a pedestal with a bottom opening of 3/8" and the convex portion.

10 In Figure 23 there is shown a device similar to that shown in Figure 5 except that in this case the sheet 35 is provided with protrusions which consist only of the convex portions 35a, i.e., there are no pedestals 35b. In this case the snap-through layer 36 is preferably made thicker to compensate for the lack of a pedestal. Although this configuration is usable, the protrusions with a pedestal 35b are much preferred because they give a better key-like "feel" under depression. The modifications shown in Figures 7-19 may also be included in the structure of Figure 23.

WHAT WE CLAIM IS:—

30 1. A keyboard assembly comprising an electrically conductive contact means on a support, an electrically conductive contactor positioned in register with but normally out of contact with the contact means, and an insulating sheet of plastics material having a plurality of protrusions formed therein, the sheet being so positioned with respect to the contactor and contact means that the protrusions normally point away from the contact means, each protrusion being adapted, when depressed, to move by snap action to a position in which it urges the contactor against the contact means, a depressed protrusion returning to its initial position after release of pressure.

50 2. A keyboard assembly having an electrically conductive contact means on a support, an insulating sheet of plastics material formed with protrusions which normally point away from the support and a circuit pattern arranged on the side of the sheet facing towards the said support and having parts registering with the said protrusions and constituting contactors, each protrusion being adapted, when depressed, to move by snap action into a position in which it urges the corresponding contactor against the conductive contact means, a depressed protrusion returning to its initial position after release of pressure.

65 3. A keyboard assembly according to claim 1, in which between the said sheet and the contactor there is a layer formed with a

plurality of holes in register with the said protrusions.

4. A keyboard assembly according to claim 1, 2 or 3, in which between each contactor and the contact means there is inserted a separating layer having a plurality of holes in register with the said protrusions, through which holes the contactor and the contact means can be brought together.

5. A keyboard assembly according to claim 1, 2, 3 or 4, in which each protrusion has a curved top surface.

6. A keyboard assembly according to claim 5, in which indicia are provided on the curved top portions of the protrusions.

7. A keyboard assembly according to claim 5 or 6, in which each protrusion comprises a pedestal, the curved top surface of the protrusion being connected to the top of the pedestal.

8. A keyboard assembly according to claim 7, in which the pedestal is of cylindrical shape.

9. A keyboard assembly according to claim 7 or 8, in which the height of the pedestal is less than the height of the said curved portion of the protrusion.

10. A keyboard assembly according to any one of the preceding claims, further comprising a button assembly for depressing the protrusions, a separate button being associated with each protrusion.

11. A keyboard assembly according to any one of the preceding claims, in which the contactor comprises an electrically conductive plastics material.

12. A keyboard assembly according to claim 1, in which the inner face of each of the protrusions has a flexible electrically conductive layer adhering thereto and constituting the contactor.

13. A keyboard assembly according to claim 12, in which the flexible conductive layer extends over the entire underside of the sheet.

14. A keyboard assembly according to claim 1, in which a circuit pattern adheres to the underside of the plastics sheet, portions of the circuit pattern acting as contactors arranged on the undersurfaces of the said protrusions.

15. A keyboard assembly according to any one of the preceding claims, in which the





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said contactor comprises a plastics binder through which are dispersed electrically conductive particles.

16. A keyboard assembly according to any one of the preceding claims, in which each protrusion, when depressed, moves by snap action to a position in which it is at least partially inverted.

17. A keyboard assembly according to claim 5 in which the curved top surface is

shaped like a portion of a sphere.

18. A keyboard assembly, substantially as herein described with reference to the accompanying drawings.

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