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(54) IMPROVEMENTS IN OR RELATING TO ACTUATING MECHANISMS FOR ELECTRICAL CIRCUIT COMPONENTS

(71) We, HEWLETT-PACKARD COMPANY of 1501 Page Mill Road, Palo Alto, California, United States of America, a corporation organised and existing under the laws of the state of California, 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 improvements in or relating to actuating mechanisms suitable for electrical circuit components.

Prior art keyboards for use with computers, calculators, data terminals and the like are available in a multitude of different configurations. However, many of them do not provide any tactile feedback to the keyboard operator to assure him that the key has been depressed sufficiently to effect a contact closure. Those keyboards which do provide tactile feedback are usually considerably more bulky than those without such feedback. Structurally, most keyboards comprise an array of complex sub-assemblies which are assembled in a certain configuration at the factory and are usually not field modifiable. These complex sub-assemblies are usually costly to assemble, making the resultant keyboard relatively expensive.

It is an object of the present invention to provide an improved actuating mechanism suitable for such keyboards.

The present invention provides an actuating mechanism for electrical circuit components comprising a key; first and second parallel shafts attached to the key; guiding means for guiding the movement of the first and second shafts; means for coacting with the first shaft to give an electrical signal in response to depression of the key by a user; resilient means for coacting with the second

shaft for exhibiting a sudden change in resilience in response to the movement of the second shaft during depression of the key and for exhibiting a substantially lesser change in resilience in response to movement of the second shaft during release of the key, thereby providing tactile feedback to the user.

Preferably the second shaft has a notch in one side and the resilient means includes cantilever spring means having a first spring rate when deflected in a first direction, a second spring rate when deflected in a second direction, and extending into the notch when the key is depressed, deflecting the cantilever spring means in the first direction.

In one actuating mechanism according to the invention, the cantilever spring means comprises first and second overlapping cantilever springs, both the first and the second cantilever springs coacting with the second shaft during deflection in the first direction and the first spring coacting with the second shaft during deflection in the second direction.

In an alternative actuating mechanism according to the invention the first shaft is hollow and has a hole through it running transverse to the longitudinal axis of the shaft; the second shaft is supported within the first shaft; and the resilient means includes a buckled spring running through the transverse hole in the first shaft and a triangular element fastened to the buckled spring in line with the second shaft.

The means for co-acting with the first shaft preferably comprises a conductive element, a spring and a support member formed from a single piece of material, the conductive element being suspended by the spring from the support member, the conductive element being positioned in line with the first shaft, and the support member being attached to the guiding means;

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and a circuit element supported in line with the first shaft and the conductive element; whereby depression of the key causes the first shaft to displace the conductive element with respect to the circuit element.

The actuating mechanism of the present invention provides tactile feedback to the operator, but is more compact than prior art devices with such feedback. A keyboard formed from a combination of a plurality of actuating mechanisms of the present disclosure and a printed circuit board, of the type hereinafter described, is not only compact, but it can easily be made in modular form so that keys can be added or removed in the field. Since the actuating mechanism comprises relatively few components and the components can be formed in arrays, a keyboard using the actuating mechanisms of the present invention is inexpensive due to the ease of assembly.

A preferred embodiment of the present invention comprises a key having a pair of parallel shafts attached to it, one for deflecting a metal plate and the other for actuating a resilient member. The metal plate and a spring attaching it to a metal sheet are formed from the metal sheet, and the metal sheet is attached to an insulating support structure. The support structure also serves as a guide for the shafts. The resilient member may be comprised of a pair of springs of differing spring rates or a single buckled spring which changes resilience suddenly when depressed by the aforementioned shaft. A printed circuit board is attached to the support structure so that the plate is deflected toward a circuit element on the printed circuit board when the key is depressed. The circuit element can be, for example, a sensing element for a non-contacting keyboard of the type described in the complete specification of our co-pending patent application Serial No. 1315885.

There now follows a detailed description which is to be read with reference to the accompanying drawings of actuating mechanisms according to the invention; it is to be clearly understood that these actuating mechanisms have been selected for description to illustrate the invention by way of example and not by way of limitation.

Figure 1a is an exploded view of an actuating mechanism according to the invention;

Figure 1b shows an alternative printed circuit board for use in the actuating mechanism of Figure 1a;

Figures 2a, 2b, 2c, and 2d are cut-away views showing the operation of an actuating mechanism according to the present invention;

Figures 3a and 3b are cut-away views showing the operation of another actuating

mechanism according to the present invention.

Figure 1a illustrates one of an array of actuating mechanisms. A key 12 is attached to two shafts, 14 and 16, which are arranged to be guided in holes 18 and 20 respectively provided in a support member 22, which is made by moulding of plastics material. A metal strip 24 has a metal plate 26 and a pair of springs 28a and 28b formed from it by a process such as chemical etching or stamping. A cantilever 30 is also formed from the metal strip 24. The metal strip 24 is held between a spacer 32 and the support member 22 and is positioned by locating pins 34. A strip 36, typically made of a material such as Mylar (R.T.M.), is sandwiched between the metal strip 24 and the support member 22 and is positioned by locating pins parallel to those illustrated. A cantilever 38, which is a part of the strip 36, overlies the cantilever 30. A printed circuit board 40 is held against the spacer 32 by screws 42 which screw into holes (not shown) in the support member 22 and hold the whole assembly together. A printed circuit transformer 44 comprising concentric spirals 46 and 48 formed on one side of the printed circuit board 40 provides a sensing element. The spirals can be provided on both sides of the board if desired. The transformer 44 is connected to driving and decoding electronics described more fully in the aforementioned copending patent application.

As shown in Figures 2a and 2c, when the key 12 is depressed by a keyboard user, the shaft 14 deflects the metal plate 26 toward the transformer 44, thereby decreasing the mutual inductance between the spirals 46 and 48, and providing a key-down signal to the decoding electronics. Other sensing elements, such as a capacitor, for example, could be used instead of a transformer; or a piece of ferrite could be attached to the metal plate 26 to increase the mutual inductance between the spirals 46 and 48. Alternatively, as shown in Figure 1b, the metal plate 26 can be used to connect a pair of contacts 45 and 47 on the printed circuit board 40. When the user releases the key 12, the springs 28a and 28b return the metal plate 26 and, therefore, the key 12 to their 'up' positions.

The shaft 16 and the cantilevers 30 and 38 are also shown schematically in greater detail in the cut-away views of Figures 2a, 2b, 2c, and 2d. Figure 2a shows the relative positions of the shaft 16 and the cantilevers when the key 12 is in the 'up' position. As the key 12 is depressed, the shaft 16 deflects the two cantilevers as shown in Figure 2b, and the user encounters increasingly greater resistance. As the cantilevers 30 and 38 are deflected downward, a tip

on 39 of the cantilever 38 is also depressed laterally so that the shaft 16 slides past the tip portion 39. The cantilever 38 then snaps into a recess 50 in the shaft 16 as the key is depressed all the way down. When this happens the user feels the sudden change in resilience as a decrease in the resistance offered by the key 12. The shaft 16 encounters resistance only from the cantilever 38 when the key 12 is released, as shown in Figure 2d, since only the cantilever 38 extends into the recess 50, and the springs 28a and 28b easily overcome the resistance of the cantilever 38 to return the key 12 to its 'up' position. Thus the resilience or spring rate of the resilient means provided by the cantilevers 30 and 38 undergoes a sudden change when deflected by the shaft 16, and the resilience is different for upward and downward movement of the shaft.

Figure 3a shows another actuating mechanism according to the invention. A key 62 is attached to a hollow shaft 64 which is guided by a support member 68. A flexible shaft 66 is also attached to the key 62. A buckled spring 70 is fastened between the support member 68 and a spacer 72, and the spring 70 passes through a hole 74 in the shaft 64. Attached to the spring 70 is a triangular deflector member 76, positioned directly under the shaft 66. A metal strip 24 including a plate 26 and springs 28a, 28b (Figure 3b), is sandwiched between the spacer 72 and another spacer 32. A printed circuit board 40 is attached to the spacer 32. When the key 62 is depressed, the shaft 64 deflects the plate 26 toward a transformer 44 as previously described with reference to Figure 1. At the same time the shaft 66 presses against the deflector member 76 until the spring 70 is deflected far enough to buckle as shown in Figure 3b. When the spring 70 thus buckles, the user feels the sudden change in resilience since the resistance offered to the shaft 66 by the deflector member 76 is greatly reduced. When the key 62 is released, the shaft 66, which has also been deflected by the deflector member 76, will glide along the surface of the deflector member 76 and will be returned to its upright, straight position by the springs 28a and 28b. Since the spring 70 is a bistable element the next time the key 62 is depressed, the spring 70 will buckle back to the position shown in Figure 3a.

Although the discussion of Figures 1, 2 and 3 has centered on a mechanism comprising a single key, the mechanisms herein disclosed can be advantageously fabricated into multi-element arrays. Thus, as suggested by Figure 1, a plurality of metal plates 26, springs 28, and cantilevers 30 can be formed in the metal strip 24; a

plurality of cantilevers 38 can be formed on the strip 36. The support member 22 and the spacer 32 can also be molded to accommodate a plurality of keys. The formation of arrays of constituent components allows a reduction in the assembly time and cost of multi-element keyboards. To increase flexibility, keys 12 may be retained in the support member 22 by arranging that a recess 15 in the shaft 14 can be engaged by a protrusion in the hole 18. Thus keys can be added or removed in the field according to the user's needs.

WHAT WE CLAIM IS:

1. An actuating mechanism for electrical circuit components comprising a key; first and second parallel shafts attached to the key; guiding means for guiding the movement of the first and second shafts; means for coacting with the first shaft to give an electrical signal in response to depression of the key by a user; resilient means for coacting with the second shaft for exhibiting a sudden change in resilience in response to the movement of the second shaft during depression of the key and for exhibiting a substantially lesser change in resilience in response to movement of the second shaft during release of the key, thereby providing tactile feedback to the user.
2. An actuating mechanism according to claim 1 wherein the second shaft has a notch in one side and the resilient means includes cantilever spring means having a first spring rate when deflected in a first direction, and extending into the notch when the key is depressed, deflecting the cantilever spring means in the first direction.
3. An actuating mechanism according to claim 2 wherein the cantilever spring means comprises first and second overlapping cantilever springs, both the first and the second cantilever springs coacting with the second shaft during deflection in the first direction and the first spring coacting with the second shaft during deflection in the second direction.
4. An actuating mechanism according to claim 1, wherein the first shaft is hollow and has a hole through it running transverse to the longitudinal axis of the shaft; the second shaft is supported within the first shaft; and the resilient means includes a buckled spring running through the transverse hole in the first shaft and a triangular element fastened to the buckled spring in line with the second shaft.
5. An actuating mechanism according to any one of claims 1 to 4 wherein the means for co-acting with the first shaft comprises a conductive element, a spring and a support member formed from a single piece of material, the conductive element being suspended by the spring from the support member, the conductive element being posi-

on 39 of the cantilever 38 is also de-
 a laterally so that the shaft 16 slides
 past the tip portion 39. The cantilever 38
 then snaps into a recess 50 in the shaft 16
 5 as the key is depressed all the way down.
 When this happens the user feels the sudden
 change in resilience as a decrease in the
 resistance offered by the key 12. The shaft
 16 encounters resistance only from the canti-
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 10 shown in Figure 2d, since only the canti-
 lever 38 extends into the recess 50, and the
 springs 28a and 28b easily overcome the
 resistance of the cantilever 38 to return the
 15 key 12 to its 'up' position. Thus the resi-
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 20 upward and downward movement of the
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Figure 3a shows another actuating mech-
 anism according to the invention. A key
 62 is attached to a hollow shaft 64 which is
 25 guided by a support member 68. A flexible
 shaft 66 is also attached to the key 62. A
 buckled spring 70 is fastened between the
 support member 68 and a spacer 72, and
 the spring 70 passes through a hole 74 in
 30 the shaft 64. Attached to the spring 70 is
 a triangular deflector member 76, positioned
 directly under the shaft 66. A metal strip
 24 including a plate 26 and springs 28a, 28b
 (Figure 3b), is sandwiched between the
 35 spacer 72 and another spacer 32. A printed
 circuit board 40 is attached to the spacer 32.
 When the key 62 is depressed, the shaft 64
 deflects the plate 26 toward a transformer
 44 as previously described with reference to
 40 Figure 1. At the same time the shaft 66
 presses against the deflector member 76
 until the spring 70 is deflected far enough
 to buckle as shown in Figure 3b. When
 the spring 70 thus buckles, the user feels
 45 the sudden change in resilience since the re-
 sistance offered to the shaft 66 by the de-
 flector member 76 is greatly reduced. When
 the key 62 is released, the shaft 66, which
 has also been deflected by the deflector
 50 member 76, will glide along the surface of
 the deflector member 76 and will be re-
 turned to its upright, straight position by
 the springs 28a and 28b. Since the spring
 70 is a bistable element the next time the
 55 key 62 is depressed, the spring 70 will
 buckle back to the position shown in Figure
 3a.

Although the discussion of Figures 1, 2
 and 3 has centered on a mechanism com-
 60 prising a single key, the mechanisms herein
 disclosed can be advantageously fabricated
 into multi-element arrays. Thus, as sug-
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 plates 26, springs 28, and cantilevers 30
 65 can be formed in the metal strip 24; a

plurality of cantilevers 38 can be formed
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 and the spacer 32 can also be molded to
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 mation of arrays of constituent components
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 in the support member 22 by arranging that
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 can be added or removed in the field accord-
 ing to the user's needs.

WHAT WE CLAIM IS:

1. An actuating mechanism for electrical
 circuit components comprising a key; first
 and second parallel shafts attached to the
 key; guiding means for guiding the move-
 ment of the first and second shafts; means
 for coacting with the first shaft to give an
 85 electrical signal in response to depression
 of the key by a user; resilient means for
 coacting with the second shaft for exhibiting
 a sudden change in resilience in response to
 the movement of the second shaft during
 90 depression of the key and for exhibiting a
 substantially lesser change in resilience in
 response to movement of the second shaft
 during release of the key, thereby providing
 tactile feedback to the user. 95

2. An actuating mechanism according to
 claim 1 wherein the second shaft has a
 notch in one side and the resilient means
 includes cantilever spring means having a
 first spring rate when deflected in a first
 100 direction, and extending into the notch when
 the key is depressed, deflecting the canti-
 lever spring means in the first direction.

3. An actuating mechanism according to
 claim 2 wherein the cantilever spring means
 105 comprises first and second overlapping
 cantilever springs, both the first and the
 second cantilever springs coacting with the
 second shaft during deflection in the first
 direction and the first spring coacting with
 110 the second shaft during deflection in the
 second direction.

4. An actuating mechanism according to
 claim 1, wherein the first shaft is hollow
 and has a hole through it running transverse
 115 to the longitudinal axis of the shaft; the
 second shaft is supported within the first
 shaft; and the resilient means includes a
 buckled spring running through the trans-
 verse hole in the first shaft and a triangular
 120 element fastened to the buckled spring in
 line with the second shaft.

5. An actuating mechanism according to
 any one of claims 1 to 4 wherein the means
 for co-acting with the first shaft comprises
 125 a conductive element, a spring and a sup-
 port member formed from a single piece of
 material, the conductive element being sus-
 pended by the spring from the support mem-
 ber, the conductive element being posi- 130



tioned in line with the first shaft, and the support member being attached to the guiding means; and a circuit element supported in line with the first shaft and the conductive element; whereby depression of the key
5 causes the first shaft to displace the conductive element with respect to the circuit element.

6. An actuating mechanism substantially as hereinbefore described with reference to the accompanying drawings.

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