

[54] **KEYBOARD SWITCH MATRIX ASSEMBLY WITH IMPROVED GUIDE MEANS FOR REDUCING TRANSFER OF BOUNDING MOTION TO MOVABLE CONDUCTOR**

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[51] Int. Cl. **H01h 13/30**

[58] Field of Search **200/5, 159 R, 159 B, 200/16 A, 166 BH, 5 A, 166 BE, 166 BF**

[56] **References Cited**

UNITED STATES PATENTS

3,221,112	11/1965	Gaynor	200/5 R
3,290,439	12/1966	Willcox et al.	200/5 A X
2,930,859	3/1960	Nolden et al.	200/16 A
3,684,842	8/1972	Boulanger	200/5 A

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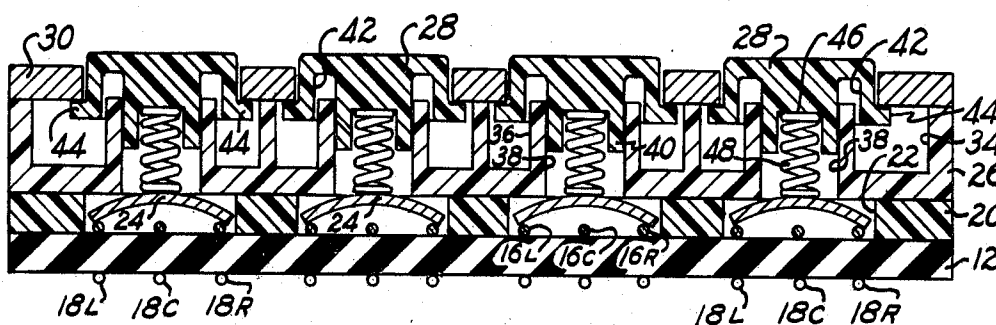
Attorney—Harold Levine et al.

[57]

ABSTRACT

A system employing a keyboard comprises a base mounting an array of key bodies each adapted to reciprocally move to cause actuation of electrical circuits. A diaphragm is employed as an electrical conductor moving into and out of engagement with underlying contacts upon actuation and deactuation of the key body. Bounding problems have been minimized while maintaining tactile feedback by locating a spring member between the key and its respective diaphragm providing increased motion differential and by providing elongated guiding surfaces which eliminate skew movement of the key. Several forms of keys and key mountings are shown embodying the elongated guideway including an elongated hub molded in the bezel plate and receiving a close fitting rod portion of the key, a separate tubular guide and close fitting plunger, and a key having tabs extending laterally therefrom, the tabs slidably received in grooves formed in the base. Another embodiment particularly useful where two or more circuits are to be actuated from the same key employs a second spring to maintain the diaphragm away from the underlying contacts until the key is depressed thereby precluding undesirable back circuits without the use of blocking diodes or the like.

18 Claims, 9 Drawing Figures



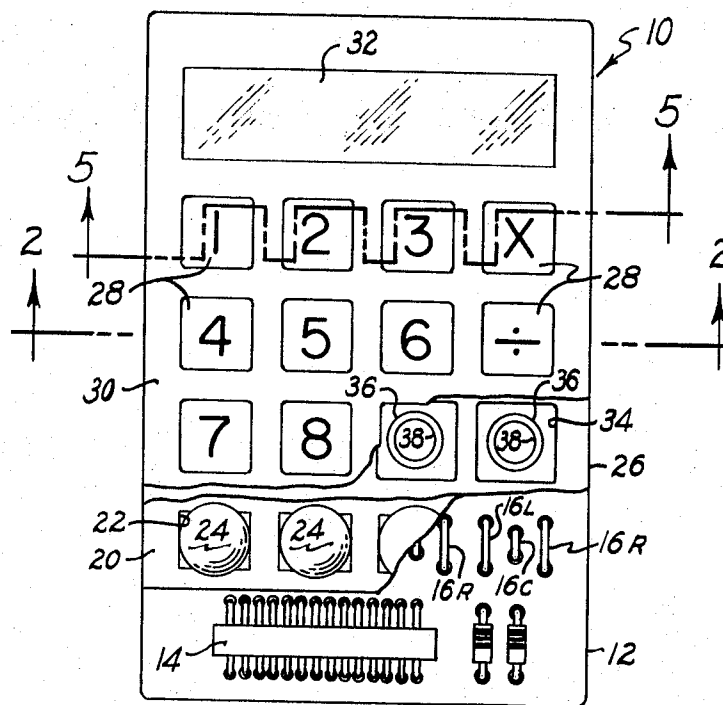


Fig. 1.

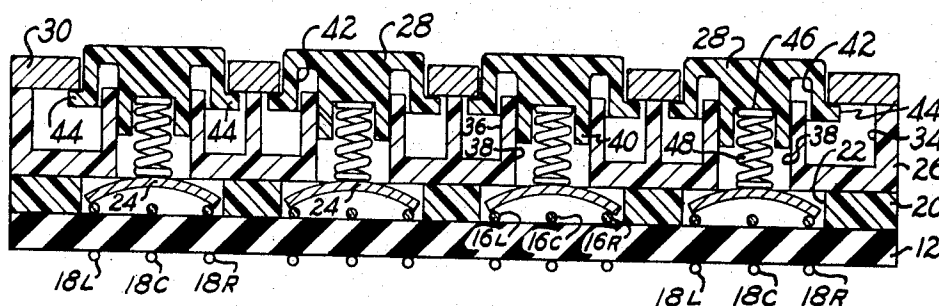


Fig. 2.

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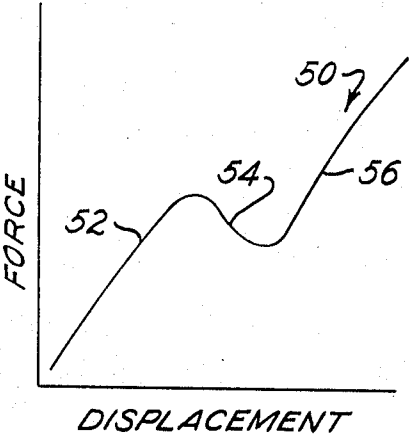


Fig. 3.

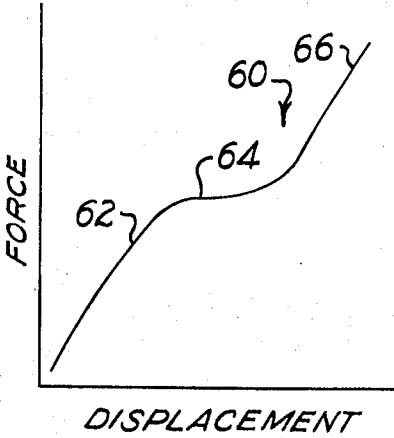


Fig. 4.

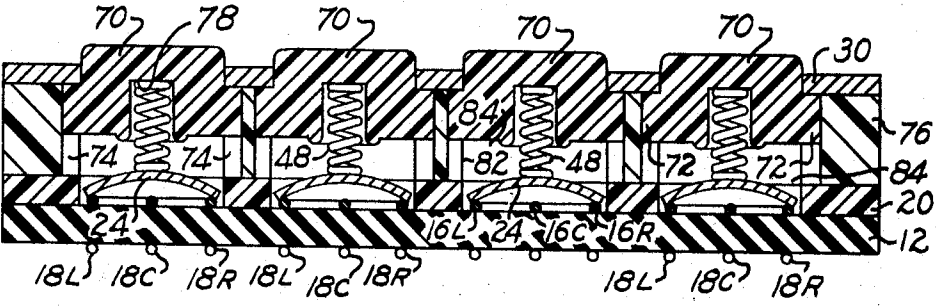


Fig. 5.

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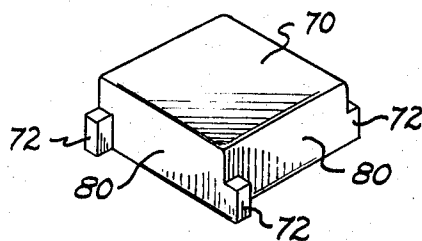


Fig. 6.

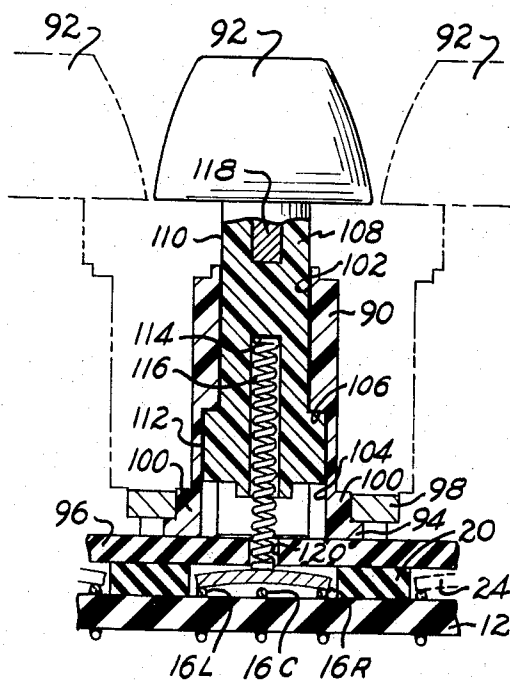


Fig. 7.

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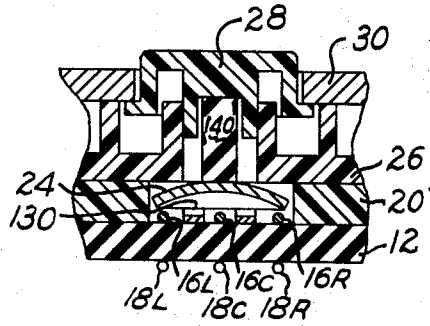


Fig. 8.

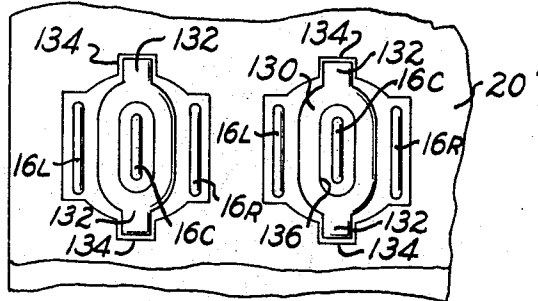


Fig. 9.

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KEYBOARD SWITCH MATRIX ASSEMBLY WITH IMPROVED GUIDE MEANS FOR REDUCING TRANSFER OF BOUNDING MOTION TO MOVABLE CONDUCTOR

This invention relates to keyboard devices and more particularly to keyboard devices of the contacting type.

In recent years there has been a wide proliferation of types of keyboard, each having certain advantages and disadvantages. For instance some elastomeric keyboards have a low profile which is advantageous for certain applications but have disadvantages such as high contact resistance and an ambiguous feel of contact actuation through the keys as well as being expensive due to the extensive gold plating required. Those employing non-contacting systems have advantages such as long life, no variation in contact resistance, no contact bounce; however, they have high standby current drain and are relatively complex due to the required associated circuitry. Keyboard devices employing diaphragms as the contact bridging conductor are, inter alia, inexpensive and reliable, provide excellent tactile feedback and are flexible in use since the diaphragm can be chosen having any of a wide range of operating forces. Such keyboards however, suffer from the disadvantage of being subject to an undesirable phenomenon known as "bounding." Bounding occurs when an operator's finger, while actuating a key, bounces and allows the respective switch to open momentarily producing a switching transient that may cause incorrect data to be fed into the apparatus controlled by the keyboard. This problem is accentuated in keyboards which have comparatively little force and movement differential. Another limitation of prior art keyboards is that they have required additional circuitry means such as blocking diodes or some type of scanning device to prevent electrical back circuits when two or more circuits are actuated by the same key.

It is an object of the invention to provide an improved keyboard system in which electrical interconnections are effected responsive to mechanical actuation. It is a further object of the present invention to provide an improved keyboard device, one which utilizes the advantage of keyboards employing diaphragms, yet one which is essentially free of bounding. Another object of the invention is the provision of a reliable, inexpensive keyboard which is also conducive to mass production. Another object is the provision of a keyboard device in which all the keys have not only the same feel of actuation but also a pleasant feel of actuation. Yet another object is the provision of a keyboard system in which back circuits are precluded without using conventional blocking diodes or scanning apparatus. Yet another object is the provision of a keyboard which has low profile, is durable, long-lived and adapted for use with various apparatus including electronic calculators, computer systems and credit card verifiers and the like.

Various additional objects and advantages of the present invention will become readily apparent from the following detailed description and accompanying drawings.

Briefly, in accordance with the present invention a keyboard device is provided comprising an array of key bodies mounted contiguous to a circuit board. The key bodies are mounted for reciprocal motion and adapted to close electrical circuits upon sufficient depression or

actuation of the key. Depression of the key causes an electrical conductor in the form of a diaphragm to bridge underlying contacts. In order to avoid bounding, as mentioned above, a condition in which the operator's finger bounces off the key body thereby generating undesirable electrical impulses, movement differential is provided by placing a spring or elastomeric member intermediate the key body and the diaphragm such that it transmits force from the key body to the diaphragm. Additionally, elongated guiding surface means is provided to preclude skew movement of the key. Several embodiments showing the guiding surface means are shown including an elongated plunger and guideway, and laterally extending tabs formed in the key body and extending into grooves in the base. In order to obviate the possibility of undesirable back circuits when two or more circuits are actuated by the same key without resorting to blocking diodes or scanning apparatus means, normally open switches, closable in a two-step operation in response to key actuation, are provided. That is, upon actuation of the key body the diaphragm will engage the output contacts prior to engagement with the signal contact. In the unactuated position, positive structural means maintains the diaphragm separated from the contacts.

In the accompanying drawings, in which several of the various possible embodiments of the invention are illustrated:

FIG. 1 is a top plan view, with parts broken away for clarity of illustration, of an electronic calculator using a keyboard according to the present invention;

FIG. 2 is a cross sectional view taken on lines 2—2 of FIG. 1;

FIG. 3 shows a Force V Displacement curve of a first diaphragm useful in the present invention;

FIG. 4 shows a Force V Displacement curve of a second diaphragm useful in the present invention;

FIG. 5 is a cross sectional view taken on lines 5—5 of FIG. 1 showing an alternative switch actuation system;

FIG. 6 is a perspective view of the key body shown in FIG. 5;

FIG. 7 is a cross sectional partial view similar to FIG. 2 but showing another alternative switch actuation system;

FIG. 8 is a cross sectional view similar to FIG. 2 but showing another alternative switch actuation system as well as means to preclude back circuits; and

FIG. 9 is a top plan view of a portion of the keyboard, with certain parts removed showing the FIG. 8 means to preclude back circuits.

Similar reference characters indicate corresponding parts throughout the several views of the drawings. Dimensions of certain of the parts, as shown in the drawings, have been modified or exaggerated for the purpose of clarity of illustration.

Referring now to the drawings, a keyboard made in accordance with the invention is shown in FIG. 1 incorporated in a calculator 10, broken away to show the relationship of the several parts with one another. Calculator 10 includes circuit board 12 which has on the bottom side thereof (not shown) a conventional conductive lead layout. Mounted on the top surface of board 12 is a calculator circuit which may take the form of a single chip housed in a 28-pin dual in line package 14. Also mounted on board 12 are a plurality of sets of contact elements 16L, 16C and 16R. These may convey

niently be formed of electrically conductive staples inserted into apertures formed in the board 12 with the ends soldered to the conductive lead layout on the reversed side thereof as indicated at 18L, 18C and 18R in FIG. 2. A diaphragm retainer plate 20 is provided with a plurality of cut out sections 22, each aligned with a respective set of contact elements. A diaphragm 24 is received in each cut out section 22 and functions as an electrical conductor bridging contacts 16L, 16C and 16R as will be explained in greater detail below. Overlying the diaphragm retainer plate 20 is a bezel plate 26 mounting a plurality of keys 28 in registry with respective diaphragms. Key retainer plate 30 serves as a cover for the calculator unit. Optoelectronic display panel 32 provides the read out section of the calculator. Appropriate symbols are placed in conventional manner on keys 28 as shown in FIG. 1. It should be realized that the keyboard can be used as well with systems other than a calculator, such as computer input, credit card verifiers and the like.

As seen in FIGS. 1 and 2, bezel plate 26 is formed with recessed areas 34 and upstanding hubs 36. Hubs 36 formed with bores 38 are centered over respective diaphragms, the bores slidably receive rod portions 40 formed integrally with key bodies 28. Recessed areas 34 allow room for keys 28 to reciprocally slide up and down. Each rod portion 40 is elongated by providing an annular groove 42 in the key body which receives hub 36 when the key is depressed. Flange 44 is provided on the keys to prevent dislodgment from the recessed area 34. Each button 28 is provided with spring seat 46 which receives one end of spring 48 while the other end contacts a central portion of diaphragm 24.

Depression of button 28 will cause compression of spring 48 and will transfer a force to diaphragm 24 which increases with key travel. Eventually sufficient force will be applied to the diaphragm to cause it to change configuration from the convex (looking down as in FIG. 1) to a generally flat configuration thus bridging the respective set of contacts 16L, 16C and 16R. Each contact 16C is connected to a signal source and contacts 16L and 16R are connected to the calculator circuitry. Actuation of the key therefore results in transmission of electrical pulses through contacts 16L and 16R.

A problem experienced in prior art devices, especially low profile keyboards having little key actuation travel, is that in using the keyboard an operator sometimes does not strike the key squarely and his finger bounces on the key. For instance, the fingernail might strike the key first depressing it and as the angle of the finger changes during actuation, the key might be released from the nail only to be depressed again by the flesh portion of the finger. While one would not observe this phenomenon with the naked eye, it nevertheless can occur causing undesirable electrical impulses to be transmitted — that is, two impulses when only one was intended.

The present invention avoids this problem in several ways. Firstly, substantially increased actuation travel is provided by using a form of a spring to transfer force from the key to the diaphragm providing both pretravel and overtravel.

Additionally, means are provided to prevent cocking or skew movement of the key. As seen in FIG. 2, rod portion 40 and bore 38 are very close fitting with just enough clearance to allow rod portion 40 to slide in the

bore. Further, the effective sliding portion of rod 40 is elongated giving increased guiding surface.

Generally, one of two different types of diaphragm is employed depending on whether or not it is desirable to provide tactile feedback. Some users prefer to "feel" actuation of the switch upon depression of the key. In order to provide this, a diaphragm having a force displacement curve as shown in FIG. 3 is employed. Curve 50 has a negative sloped portion 54 of decreasing force with increasing displacement located between two portions 52, 56 of increasing force with increasing displacement. That is, as the key is depressed, the finger senses the increasing force required during portion 52; however, portion 54 gives a markedly different sensation due to the decreasing force required for that displacement. This portion of the displacement is desirable for contact actuation so that the operator "feels" actuation of the switch.

Other users prefer to minimize tactile feedback. This can be accomplished as shown in the force displacement curve of FIG. 4 by employing a diaphragm having a relatively flat portion 64 between portions 62, 66 of increasing force with increasing displacement. While it is desirable to have a portion of the curve having increased displacement per unit of force to give a rapid contact closure and to minimize criticality of contact location this curve does avoid the audible click associated with the diaphragm of FIG. 3. Either type of diaphragm may be used in this FIGS. 1, 2 embodiment. Upon depression of a key body 28 by an operator, a substantial amount of key movement is required before sufficient force is applied to diaphragm 24 to cause it to actuate or flatten out and bridge the contacts. The amount of this movement can be chosen by using a spring 48 having a particular spring rate and length in conjunction with a particular diaphragm. It has been found that diaphragms having a rating of 1½ to 8 ounces are particularly well suited for keyboards. A rating of a certain number of ounces refers to that force required to actuate or flatten the diaphragm. With the range of diaphragm rating a spring rate of up to five pounds per inch has been found to be most useful. As the spring rate for a given spring is decreased, the problem of bounding is also decreased. On the other hand, the higher the spring rate the more accurate the determination of the position of the key upon actuation. An example of a device made in accordance with the FIGS. 1, 2 embodiment employed a diaphragm of the FIG. 3 type, one half inch in diameter having a rating of three ounces. Spring 48 was chosen having a spring rate of 4 pounds per inch. 1½ ounces were required to initiate key movement and 3 ounces were required for actuation. The total displacement of the key was 0.075 inches with 0.025 – 0.050 inches pretravel, approximately 0.025 inches between actuation and the point where the diaphragm returned to its original configuration (the release force chosen to be from 40 to 50 percent of the actuation force) and 0.050 – 0.025 inches of overtravel. This resulted in a key system in which the operator was able to clearly discern the moment of switch actuation (actual, not simulated, tactile feedback) yet due to the movement differential, there was no evidence of any bounding. That is, even though the finger of the operator may have bounded off the keys, this was not transferred to the switch.

It was also found that clearance between the rod portion 40 and bore 38 should be between 0.002 and 0.006

inches, 0.004 being preferred, to eliminate the possibility of skew movement.

Another embodiment is depicted in FIGS. 5 and 6. As seen in FIG. 6, key 70 which has a generally rectangular cross section perpendicular to its direction of reciprocal motion, is provided with a plurality of ears or tabs 72 which extend laterally from each corner thereof and are received in grooves 74 formed in bezel plate 76. The keys are locked in place by plate 30. Spring 48 is received in seat 78 as in the FIG. 2 embodiment. As in the FIG. 2 embodiment, the clearance between sidewalls 80 of key 70 and the sidewalls 82 of recessed area 84 is only enough to permit sliding movement of key 70 in recessed area 84. Ears 72 provide additional guiding surfaces and preclude skew movement.

Another embodiment is illustrated in FIG. 7 which employs the same circuit board 12, diaphragm retainer plate 20, diaphragms 24, and sets of contacts 16L, 16C and 16R as in the previous embodiments. In this embodiment, however, separate elongated hubs 90 are provided for each key 92. Hub 90 is provided with an annular flange 94 locked between bezel plate 96 and hub retainer plate 98. Key portions 100 are provided to prevent rotation of hub 90. Hub 90 is provided with bore 102 and slots 104, the junction 106 therebetween serving as a stop limiting outward movement of plunger 108 as well as preventing rotational movement of plunger 108. Plunger 108 is formed of diameter portion 110 and key portions 112 closely fitting within respective bore 102 and keyways 104. Seat 114 formed within plunger 108 receives one end of spring 116. Key 92 is attached to plunger 108 in a conventional manner as by use of tang 118. In this instance when an extremely low profile is not required, it is preferred to maintain the length to diameter ratio of that portion of the plunger which is in sliding contact with the bore of hub 90 to approximately $2\frac{1}{2}$ to 1 or higher. In this embodiment the clearance between diameter portion 110 and bore 102 is between 0.003 and 0.011 inches, 0.007 being preferred to eliminate the possibility of skew movement. Apertures 120 are provided in plate 96 to permit spring 116 to pass therethrough.

FIGS. 8 and 9 show another embodiment of the invention in which means are provided to prevent occurrence of back circuits where more than one circuit is controlled by a diaphragm. FIG. 8 is similar to FIG. 2 and includes the same circuit board 12, a similar diaphragm retainer plate 20', diaphragm 24 and contacts 16L, 16C and 16R. Also the same are bezel plate 26, key bodies 28 and key retaining plate 30. Located intermediate circuit board 12 and diaphragm 24 is a wave spring member 130 which raises the diaphragm, when in the at rest position, off of contacts 16L, 16C and 16R. Spring 130 is provided with ear portions 132 received in notches 134 in diaphragm retainer plate 20' to maintain it in its proper position. Spring 130 is preferably elliptical in shape having a cut out section 136 to straddle contact 16C. Spring 130 can be formed of any good spring material such as beryllium copper or the like, or it could be formed of elastomeric material.

Spring 130 is chosen so that it will exert sufficient force on diaphragm 24 to maintain it separated from contacts 16L, 16C, 16R when the key body is in its at rest nonactuated position and also to prevent diaphragm 24 from engaging the contacts upon a predetermined amount of vibration from handling of the board. When button 28 is depressed, however, force is

exerted through spring member 140 overcoming the opposing bias of spring 130 causing diaphragm 24 as a first step to bridge outer contacts 16L, 16R. Continued depression of the key results in transferring sufficient force to cause actuation or flattening of the diaphragm thereby bridging all three contacts and permitting an electrical impulse to pass from the signal contact 16C through the diaphragm to the two output contacts 16L and 16R.

Another feature shown in FIG. 8, in place of a coil spring is a rod 140 of elastomeric material. Use of this type of spring member decreases the total actuating displacement of the key 28 but increases the accuracy of the position of the key at actuation and increases tactile feedback.

Thus it will be seen that the instant invention avoids the disadvantages attendant with prior art devices mentioned supra, essentially eliminating bounding by providing movement differential along with elongated guiding surfaces for key bodies. Further, a reliable yet inexpensive solution has been provided for precluding the occurrence of back circuits in multipole type switches.

As many changes could be made in the above constructions without departure from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawings, shall be interpreted as illustrative and not in a limiting sense, and it is also intended that the appended claims shall cover all such equivalent variations as come within the true spirit and scope of the invention.

It is to be understood that the invention is not limited in its application to the details of construction and arrangement of parts illustrated in the accompanying drawings, since the invention is capable of other embodiments and of being practiced or carried out in various ways. Also, it is to be understood that the phraseology or terminology employed herein is for the purpose of description and not of limitation.

I claim:

1. A keyboard device comprising:

a base;

a plurality of key bodies mounted on the base for reciprocal motion, the key bodies having a generally rectangular cross section perpendicular to the direction of motion;

at least two electrical contacts mounted on the base for each key body;

a bridging electrical conductor movable into and out of engagement with each said at least two electrical contacts, said conductor movable into engagement with said contacts upon a predetermined amount of force transferred from said key body;

guiding means for reducing the transfer of bounding motion to the conductor by preventing skewing motion of the key body, the guiding means includes a tab extending laterally from each corner of the rectangular cross section of the key body, said base including a groove for each tab, each tab slidably received in its respective groove.

2. A keyboard device comprising:

a base;

a plurality of key bodies mounted on the base for reciprocal motion;

at least two electrical contacts mounted on the base for each key body;

a bridging electrical conductor movable into and out of engagement with each said at least two electrical contacts, said conductor movable into engagement with said contacts upon a predetermined amount of force transferred from said key body;

guiding means for reducing the transfer of bounding motion to the conductor by preventing skewing motion of the key body, the guiding means for each key includes a generally cylindrical element mounted in the base, said element having an axially extending bore, a plunger slidably received in said bore and movable toward and away from the electrical conductor, the plunger having a diameter which is approximately one-third of the length of the bore and the clearance between the plunger and the bore between 0.002 and 0.006 inches.

3. A keyboard device according to claim 2 in which the means for reducing bounding includes a spring member placed intermediate the plunger and the conductor.

4. A keyboard device according to claim 3 in which the conductor is a diaphragm having a negative sloped portion in its force displacement curve thereby producing tactile feedback.

5. A keyboard device according to claim 4 in which the diaphragm requires an actuating force in ranges of approximately 1½ ounces to 8 ounces.

6. A keyboard device according to claim 5 in which the spring rate of the said spring member is less than approximately 5 pounds per inch.

7. A keyboard device according to claim 3 in which a bore having a closed end is provided in the plunger and the spring member is located in the bore and extends beyond the key body when there is no force applied to the spring member.

8. A keyboard device according to claim 7 in which the spring member is a helical spring thereby providing movement differential.

9. A keyboard device according to claim 7 in which the spring member is a solid elastomeric element thereby enhancing tactile feedback.

10. A keyboard device according to claim 3 in which the conductor is a diaphragm having a generally positive sloped force displacement curve throughout the displacement used in the keyboard device thereby producing noiseless operation of the diaphragm.

11. A keyboard device according to claim 2 in which means are provided to maintain the electrical conductor away from the contacts when the key body is in the unactuated position.

12. A keyboard device according to claim 2 in which the clearance between the plunger and the bore is nominally 0.004 inches.

13. A keyboard device comprising:

a base of generally rectangular configuration in plan view, the base having a plurality of apertures formed therein, an annular hub portion mounted in the base about each aperture to provide an extended guideway;

a plurality of key bodies, one for each aperture, each body having an extended cylindrical portion closely and slidably fitted in a respective aperture, first spring seating means formed in the distal end of the cylindrical portion;

a circuit board located beneath the body and provided with at least two peripherally located

contacts and one centrally located contact for each key body and located in alignment therewith;

electrical conductor retaining means located intermediate the circuit board and the body, the retaining means including a pocket and second spring seating means for each set of two output and one power supply contacts;

an electrical conductor overlying each set of two output contacts and one power supply contact and adapted to move into and out of bridging engagement with the three contacts;

a first spring member seated in the first spring seating means and applying a first bias to the electrical conductor in a direction tending to cause bridging engagement of the three contacts;

a second spring member underlying each electrical conductor and seated in the second spring seating means and applying a bias to the electrical conductor in a direction tending to prevent bridging engagement of the three contacts, the bias of the second spring means lifting the electrical conductor away from the circuit board when the key is unactuated, upon actuation of the key the conductor moving into bridging engagement of the two output contacts prior to engagement with the centrally located power supply contact thereby preventing undesirable back circuits.

14. A keyboard device according to claim 13 in which the second spring means is a generally elliptically shaped wave member having a centrally located aperture larger than and circumscribing the centrally located contact and two tab portions generally located on the major axis of the member and the tab portions extending into the second spring seating means.

15. A keyboard device according to claim 13 in which the electrical conductor is a diaphragm.

16. A keyboard system comprising:

a circuit board having a plurality of sets of contacts mounted thereon, each set including at least two output contacts and one signal contact;

an electrical conductor mounted over each set of contacts and adapted to move into and out of engagement with the contacts of the set;

a generally elliptically shaped wave spring member provided for each set of contacts having a centrally located aperture larger than and circumscribing at least one of the contacts of a set and two tab portions generally located on the major axis of the member, spring seating means for each spring member, the tab portions extending into the spring seating means thereby maintaining the conductor out of engagement with its set of contacts in the unactuated state; and

keyboard actuation means to cause the electrical conductor to move toward its set of contacts against the bias of the said wave spring member.

17. A keyboard system according to claim 16 in which the electrical conductor is a diaphragm, the output contacts are mounted in alignment with the outer peripheral portion of the diaphragm, the signal contact is mounted in alignment with the center portion of the diaphragm, the wave spring member circumscribing the signal contact, whereby actuation movement of the diaphragm toward its set of contacts will result in engagement of the diaphragm with the output contacts prior to engagement of the diaphragm with the signal contact.

18. Calculator apparatus comprising:
a housing, the housing having a key array panel and
a read out panel;
a circuit board mounted in the housing having calcu- 5
lator circuitry and a plurality of sets of contacts
mounted thereon, each set including at least one
output and one signal contact;
a movable electrical conductor mounted over each
set of contacts and adapted to move into and out
of engagement with its set of contacts; 10
a plurality of key bodies, one for each conductor
mounted on the circuit board each key body in
alignment with a respective conductor; and

means for reducing the transfer of bounding motion
to the conductor including guiding means for each
key body including a generally cylindrical element
mounted in the housing, said element having an ax-
ially extending bore, a plunger slidably received in
said bore and movable toward and away from the
electrical conductor, the plunger having a diameter
which is approximately one-third of the length of
the bore and the clearance between the plunger
and the bore between approximately 0.002 and
0.006 inches.

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