

- [54] **KEYBOARD, DIGITAL CODING, SWITCH FOR DIGITAL LOGIC, AND LOW POWER DETECTOR SWITCHES**
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- [73] Assignee: **Flex Key Corporation**, Gloucester, Mass.
- [22] Filed: **May 18, 1971**
- [21] Appl. No.: **144,453**

Related U.S. Application Data

- [63] Continuation-in-part of Ser. No. 888,758, Dec. 29, 1969, abandoned, which is a continuation-in-part of Ser. No. 801,438, Feb. 24, 1969, abandoned.
- [52] U.S. Cl. **200/166 C, 200/159 B, 200/166 PC, 200/166 H, 200/86 R, 200/83 R, 200/5 A**
- [51] Int. Cl. **H01h 1/20, H01n 1/50, H01h 1/04**
- [58] Field of Search **200/166 C, 166 H, 159 R, 200/159 B, 168 G, 86 R, 166 PC, 5 R, 5 A, 83 R, 83 N; 179/90 K**

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Primary Examiner—H. O. Jones

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[57] ABSTRACT

Electric switches are described in which a resilient, electrically conductive, elastomeric member is spaced adjacent but apart from contact means; among features are the elastomeric connector: of sheet form; on metal contacts as a movable contact bridge; defining a simple and durable multiple switch array including a keyboard, a digital coding assembly and a detector; and as the means, especially with proper selection of distributed conductive particles in the elastomer for limited conductivity, of eliminating the electrical effects of bounce in solid state electronic logic circuitry and the like. Fabrication of the switch as a simple, thin compact laminate using printed circuit boards is shown using the preferred silicone elastomer and carbon filler. In preferred embodiments pressure against conductive elastomer sheet means will cause it to connect to a contact element conductively and release of pressure will cause the sheet means to disconnect. The sheet means can be used as a floating connection for one or more circuit elements, and in this form has particular application in a keyboard assembly, particularly in connection with replaceable printed circuit boards and in digital coding techniques with a single printed circuit board. Preferably, the sheet means resiliently, reversibly deforms from first to second conditions, typically engaging the contacts in the deformed or bulged condition. Preferably in one condition the sheet means takes a planar form, positioned by a spacer layer from the contacts. And preferably the contacts are elements of a printed circuit.

33 Claims, 22 Drawing Figures

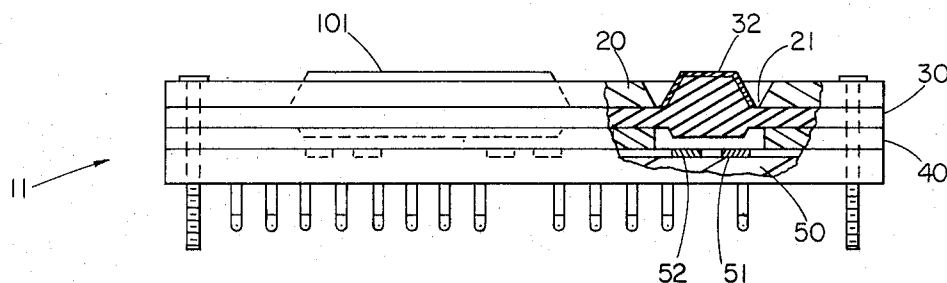


FIG 1

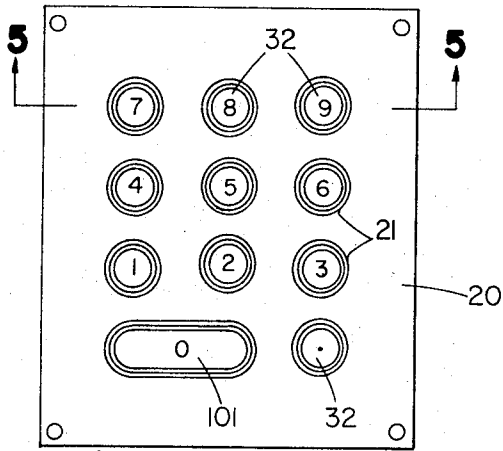


FIG 3

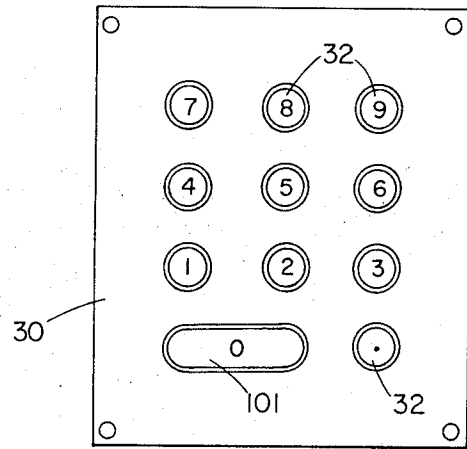


FIG 4

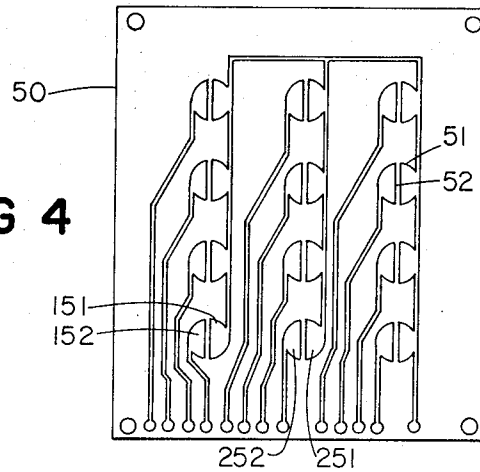


FIG 2

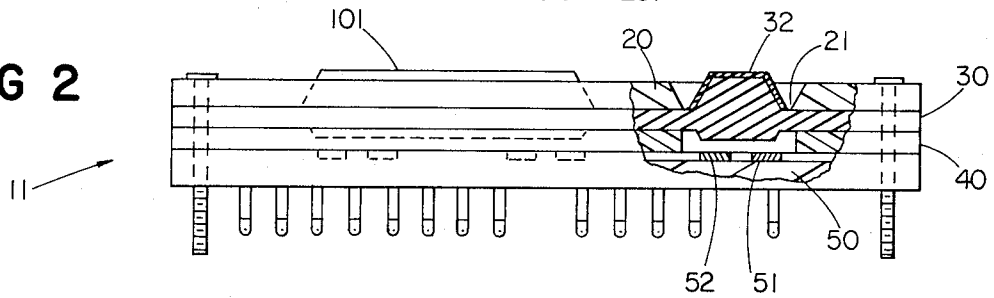
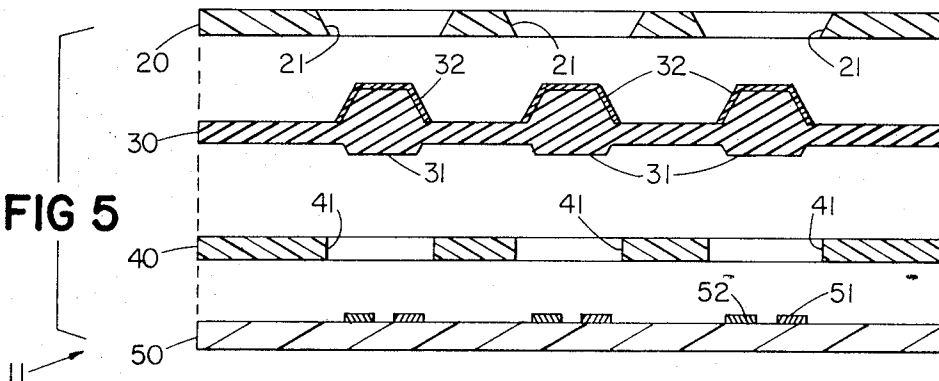
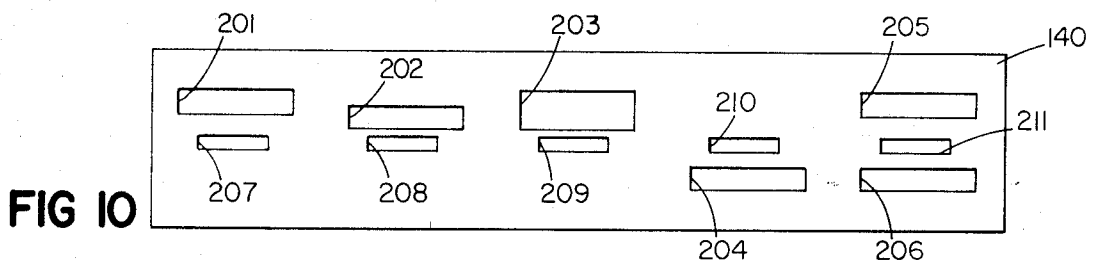
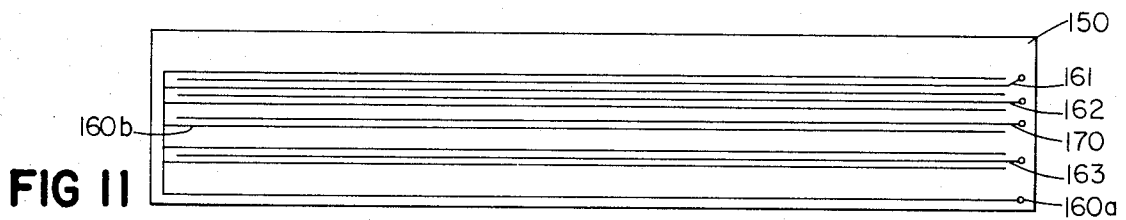
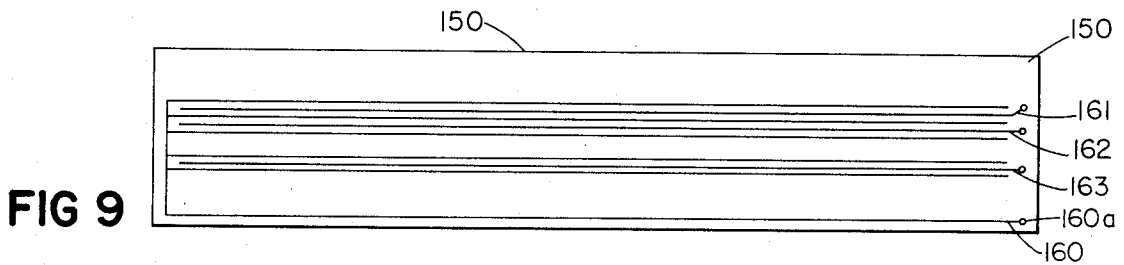
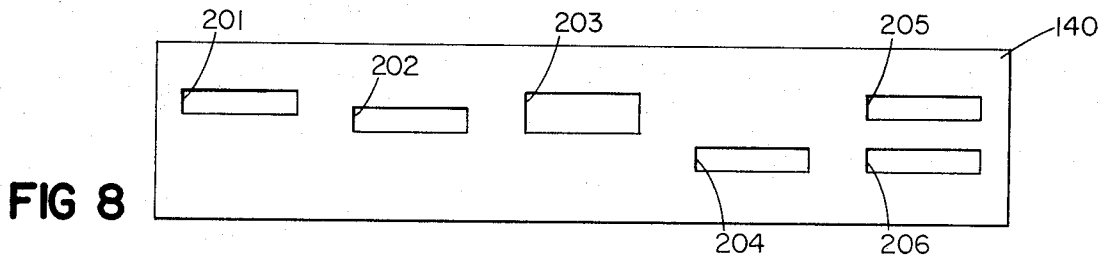
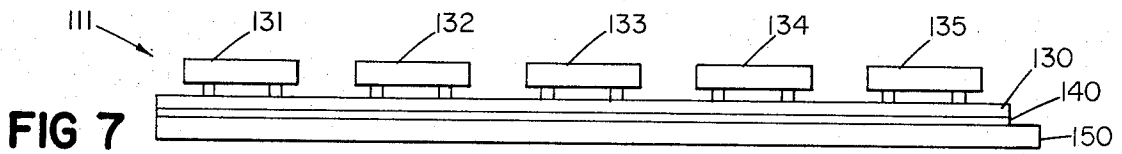
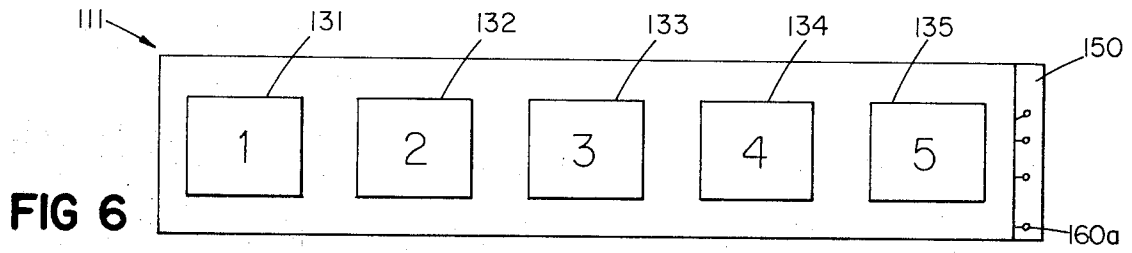


FIG 5





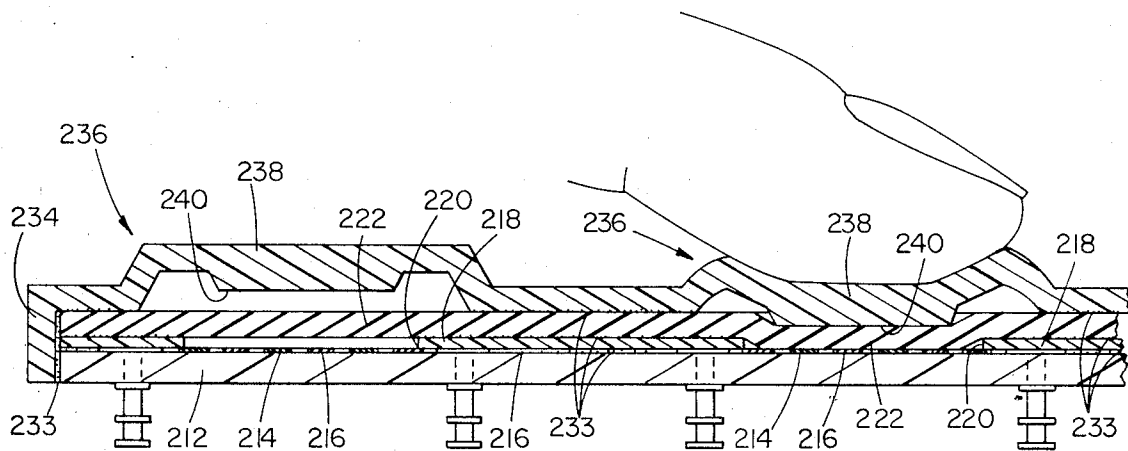
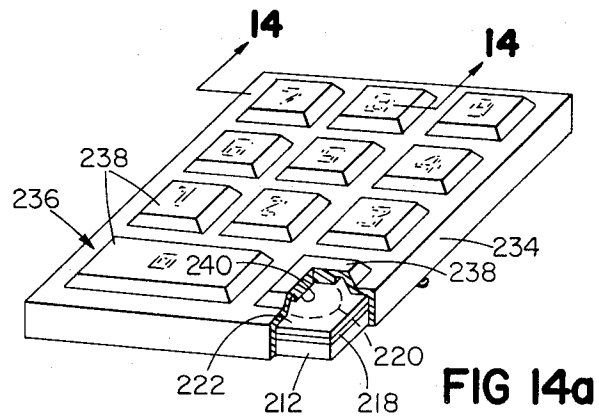
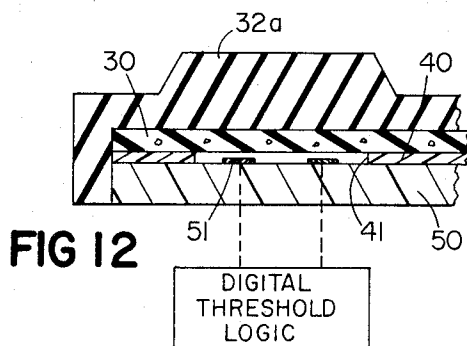
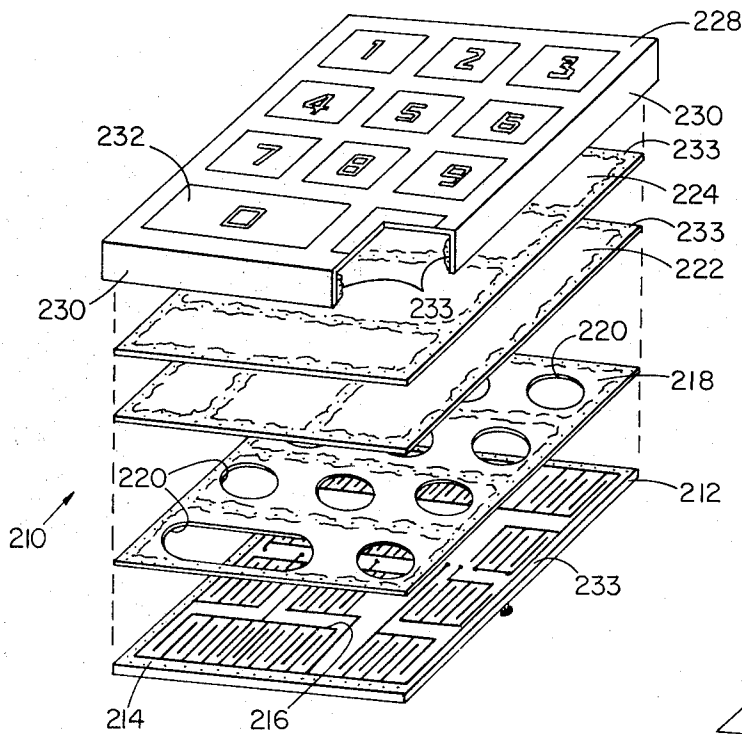


FIG 19

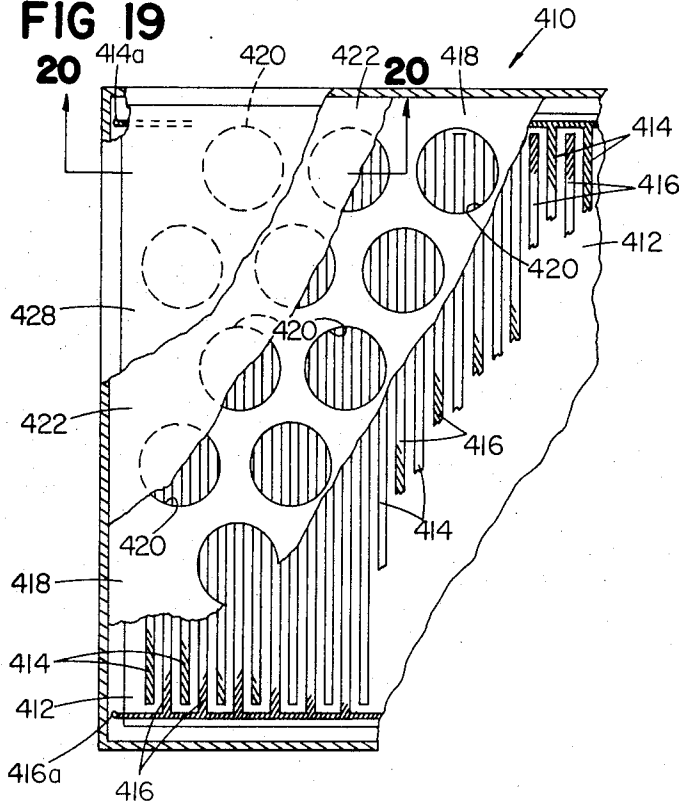


FIG 21

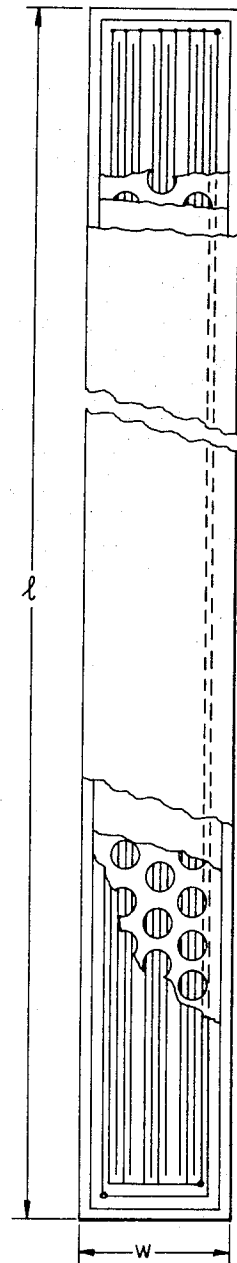


FIG 13

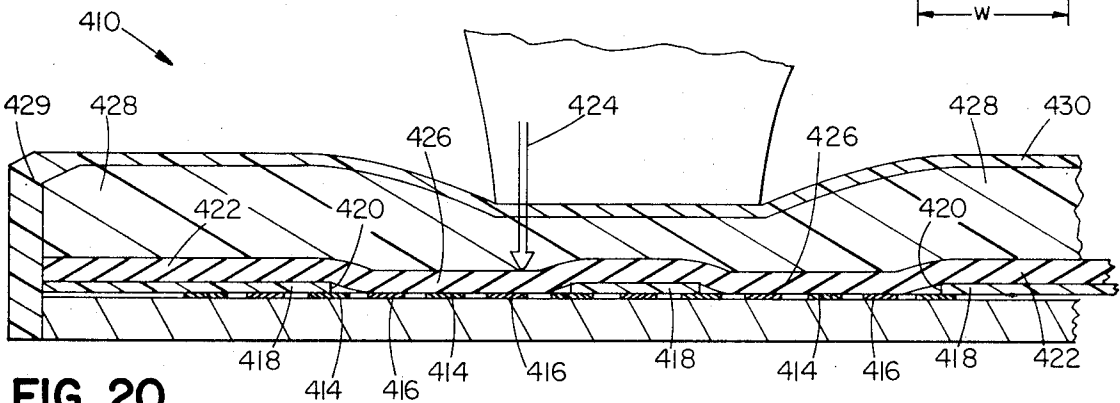
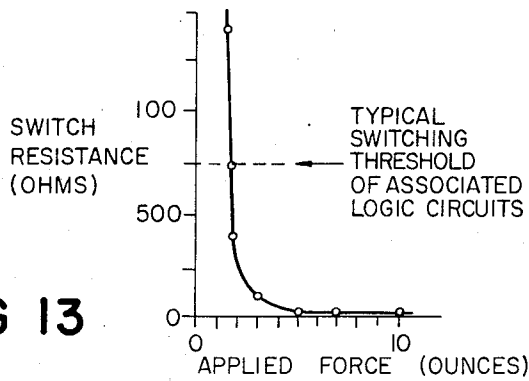


FIG 16

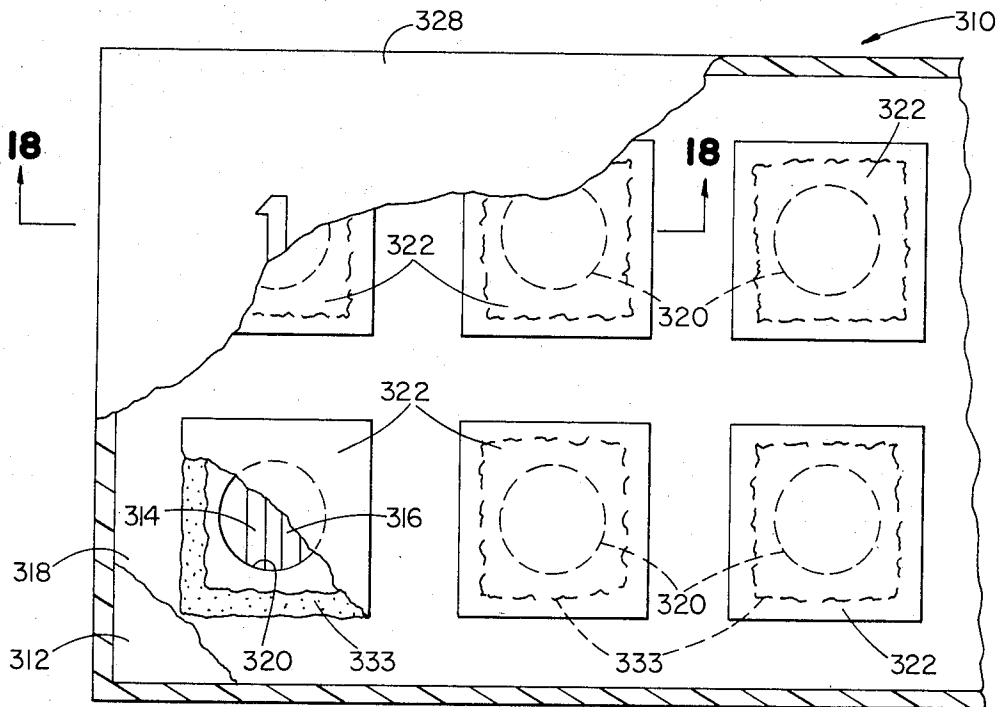
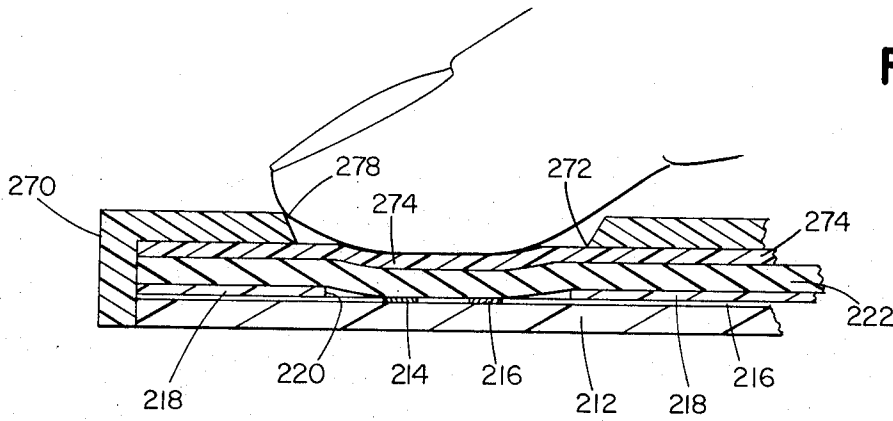


FIG 17

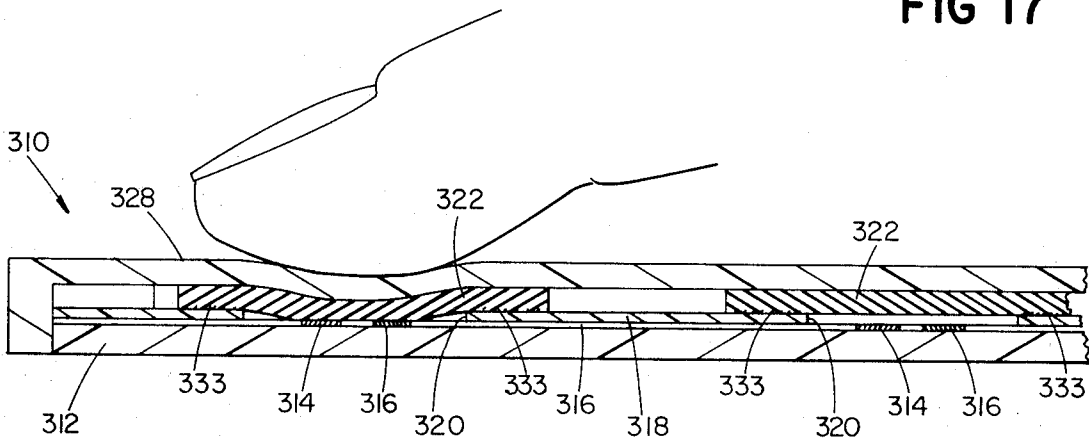


FIG 18

KEYBOARD, DIGITAL CODING, SWITCH FOR DIGITAL LOGIC, AND LOW POWER DETECTOR SWITCHES

BACKGROUND OF INVENTION

This is a continuation-in-part of my prior copending application, Ser. No. 888,758 filed Dec. 29, 1969 and of my prior copending application, Ser. No. 801,438 filed Feb. 24, 1969, now abandoned.

FIELD OF INVENTION

This invention solves problems encountered in digital coding, in manual keyboards, in switches for producing signals for use by solid state electronic digital logic circuitry and in low power detector circuits.

DESCRIPTION OF PRIOR ART

In the switching of low power level input signals, as for instance associated with solid state electronic circuits, there is a problem of "contact bounce;" this is true for instance when the input interface circuits of transistor and integrated circuit logic systems require switching of a few milliamperes current at 30 volts or less. This "bounce" is well known, and concerns the small fraction of a second of initial (or final) engagement of the contact surfaces. It relates both to mechanical variability of engagement, including mechanical transient rebound and to the attendant detrimental electrical effects, especially the effect of erratically varying of conductivity through the switch. Such variability can cause generation of multiple pulses when only one pulse is desired, and other problems as well. Usually "bounce" has in the past been assumed to be inherent in switches that are suitable for the applications mentioned. This has either placed limitations on the usefulness of the switch or required additional elements in the circuit for dealing with the problem.

Other problems have been the expense of manufacturing suitable switches, limitations on their ruggedness and life, draw-backs in their bulk, electromagnetic interference, and other requirements placed upon the equipment with which they are used.

One object of this invention is to provide such a switch which is "bounceless" in the electrical sense of avoiding the electrical effect of initial mechanical variability of engagement.

Another object of this invention is to provide such a switch with improved life and lower cost.

A further object of this invention is to provide such a switch which will have reduced electromagnetic interference.

Yet other objects of this invention are to provide a switch which can readily utilize printed circuits as a component part to provide a keyboard assembly and to provide a digital coding assembly with changeable logic codes.

A further object of this invention is to provide a switch which is adapted for use to provide input to digital logic circuitry.

Other objects and advantages of this invention will be apparent from the description and claims which follow, taken together with the appended drawings.

SUMMARY OF INVENTION

According to certain important aspects of the invention resilient, electrically conductive elastomer is positioned above two circuit elements to be connected, and functions as a conductive bridge.

According to one such aspect, sheet means of an elastomer having electrically conductive particles distributed therethrough is spaced adjacent but apart from a pair of contact elements so that pressure applied against the sheet means will cause it to connect the elements, thus providing a bridging conductive path through the particle-containing elastomer, and release of pressure will cause the sheet means to disconnect from the element and open the path. In various preferred embodiments of this aspect the elastomer is carbon filled and the sheet means has substantially the electrical resistance of carbon-filled silicone and fluorosilicone elastomers.

According to another aspect of the invention a keyboard utilizing bridging comprises a separator sheet below a conductive sheet means and followed by an electrical circuit board having a plurality of pairs of spaced contacts, the separator sheet having openings registrable with pairs of elements, so that pressure applied and released against the portion of sheet means above a pair will cause that portion to press against the pair to provide a bridging conductive path and to disconnect the element and open the path. In preferred embodiments of this aspect of the invention: the conductive sheet means is provided on its outer surface with an insulating layer at least in alignment with the openings, and the conductive sheet means is provided on its outer surfaces with buttons registrable with the openings.

According to another aspect of the invention a digital coding assembly utilizing bridging comprises a separator layer below the sheet means and having a selected pattern of apertures, this followed by an electrical circuit board having on its upper surface a common circuit element interlaced with a plurality of individual circuit elements, pressure against portions of the sheet means bridging the circuit elements exposed by the apertures, and release of pressure opening the bridging path. In preferred embodiments of this aspect: the conducting pattern for all circuit elements is on the upper surface of the board; the common circuit element comprises a series of parallel branches with each individual circuit element disposed between a different pair of branches; and apertures are arranged so that one special circuit element is always connected to the common element by depression of the conductive sheet means at any actuation point and preferably apertures for the special element are smaller than the unit apertures for the other circuit elements thus providing for a delayed action.

According to still another aspect an electric switch for producing a signal for use by solid state electronic digital logic circuitry employs a movable bridge means which is resilient and electrically conductive, made of elastomer with conductive particles distributed therethrough. The bridge means is spaced retaining adjacent but apart from the pair of contact elements so that motion of the bridge means against the contact elements will cause the elements to be connected conductively through the particle-containing elastomer and

reverse motion will cause disconnect, the switch enabling production of a signal without electrical bounce effects. In various preferred embodiments of this aspect: the particles are of non-metallic conductive material, limiting the conductivity of the path; the particles comprise carbon filler in the elastomer; the contact elements are printed circuits on a printed circuit board while non-moving portions of elastomer integral with the bridge means are supported by the board in insulated condition from the circuits, these portions retaining the bridge means in its spaced position absent the pressure; neighboring portions of elastomer integral with the bridge means extend to various sides of the bridge means and together therewith comprise sheet means, the direction of movement of the bridge means being normal to the direction of extent of the sheet means and the conductivity path being in the direction of such extent; and the just mentioned arrangement in which the elastomer portion defining the bridge means is sized for deflection by a finger of the human hand.

According to certain other aspects of the invention there are resilient, flexible electrically conductive sheet means of electrically conductive elastomer spaced adjacent but apart from contact means, so that pressure applied against the sheet means will cause it to connect conductively to the contact means and release of pressure will cause the sheet means to disconnect from the contact means. According to one such aspect, positioning means positions the sheet means so that a first portion is adjacent but apart from the contact means and the first portion is free to move relative to neighboring portions to connect and disconnect. In preferred embodiments of this aspect: the neighboring portions support the first portion in spaced position in the absence of external operating pressure, i.e., the switch is of the normally open type; the portion is adapted for manual pressure, the portion being covered by an insulating layer; an outer member exposes the insulating layer for application of actuating pressure to the portion; the layer is in the form of a button accessible to the finger; this button is resiliently deformable, providing travel; this button is thin-walled and hollow; there are a plurality of pairs of electrical contact elements and a plurality of sheet portions free to move against respective contact elements; these contact elements are part of a printed circuit; and these contacts are all adapted for completion of the same circuit to provide a detector switch.

According to certain still further aspects of the invention, portions of electrically conductive elastomer are positioned adjacent but spaced apart from respective circuit means carried on a non-conductive base. The elastomer portions are free to move and press against the printed circuit means in response to pressure applied to the portions, the portions being associated with outer insulative pressure-transmitting means for actuation by externally applied pressure. In a preferred embodiment of this aspect the elastomer portions are carbon filled so that when pressure is applied to a portion the element is connected with limited conductivity.

In other preferred embodiments the elastomer is homogeneous except for a graphite lubricant on the contacting surface.

Although the contact sets to be used with the resilient, electrically conductive elastomer according to this invention may be either metal or other conductive material, metal is preferred since elastomer to metal contacting exhibits better mechanical action in most instances. Further, where the metal contact is fixed, external connections are simplified and coding readily changed, e.g., by changing the metallic contact pattern on a printed circuit board.

Materials which can be used for the resilient, electrically conductive connecting elastomer include commercially available electrically conductive silicone or fluorosilicone elastomers. Such an elastomer when carbon filled has the following typical properties:

Electrical Resistivity:	7 ohm-cm
Tensile Strength:	750 psi
Elongation:	200% to 300%
Hardness:	58 (Shore A)

The limited conductivity obtained by use of such non-metallic particles as carbon in the elastomer is found to produce electrical properties favorable to elimination of bounce in the present context, and is especially preferred when a movable bridging element, in general, and preferably a bridging element formed as sheet means, engages a pair of contacts, preferably printed circuit contacts. In the example of conventional logic circuitry, for instance, when the resistance of the elastomer is of a value in the range represented by carbon-filled silicone or fluorosilicone elastomers, the initial engagement of the elastomer with the contact (when erratic variations occur) is in a resistance range above the range which permits flow of an effective current — i.e., a current which exceeds the logic threshold. By the time sufficient pressure is exerted at the contact (with attendant deformation of the elastomer, both of which are time-dependent) to reduce the resistance to permit effective flow of current, the system is stabilized, and relatively free of erratic tendencies.

In other instances, as where the number of pulses does not matter, or otherwise where less strict bounds are set, other electrically conductive elastomers are useful, although the particular selection of ingredients are still advantageously made with the same principle in mind.

As thus suggested conductive elastomers may be filled with finely divided metallic particles to obtain lower resistivity valves. Thus, silicone or fluorosilicone elastomer when filled with metallic silver particles has the following typical properties:

Electrical Resistivity:	0.001 to 0.010 ohm-cm
Tensile Strength:	250-400 psi
Elongation:	60% to 150%
Hardness:	30 to 60 (Shore A)

One embodiment of this invention is adapted for use in a decimal keyboard. The keyboard assembly comprises a sheet of resilient electrically conductive elastomeric material, a thin insulating separator mask and a board having a plurality of electrical contacts. Pressure on a selected portion causes it to extend through the mask and connect a set of contacts on the board. Release of pressure permits the portion to return to its original position. Low operating force

values, e.g., less than 6 ounces and small displacements, e.g., one-sixteenth of an inch or less, are feasible with this design. Such a keyboard switch design also automatically provides sufficient sealing against dirt and foreign matter. The switching action is bounceless, the construction simple and inexpensive and electromagnetic interference reduced. This switch is readily adapted for use with printed circuits and whether a single circuit or a multiplicity of such switches is used, the invention provides flexible coding by simple changing of the printed circuit boards.

In another embodiment of this invention, digital coding is achieved by use of a sheet of resilient, electrically conductive elastomeric material, a thin insulating separator mask coded by apertures in a selected pattern and a single circuit board printed on one side with a common circuit element interlaced with a plurality of individual circuit elements. Pressure on the conductive sheet above the selected apertures will provide connection of the common circuit element to the desired individual elements, thus providing coding. The coded mask is provided with the proper pattern of apertures to register only with the circuit elements required by the code.

Where more than a single circuit is to be closed by the activation of a particular button, as is generally the case for a coded system, it is advantageous to employ a mechanism for assuring that all regional circuit elements are contacted during activation of the button. Such a mechanism may be comprised of separate buttons incorporating springs, pivots or levers arranged so as to translate the manually applied actuating force more evenly onto the described resilient switching device.

The switch of this invention may also be constructed such that the contacting action is accomplished through a sliding, wiping or rolling action of the movable member. For example, a switch could be constructed of a fixed circuit element having at least one contact and a flexible, resilient, electrically conductive, non-metallic member adapted to slide, wipe or roll against said element to cause electrical connection. This can occur with resilient local deformation of a sheet-form conductive elastomer member as it progressively bulges down to engage the contact.

BRIEF DESCRIPTION OF DRAWINGS

FIG. 1 is a plan view of a keyboard assembly made in accordance with the present invention;

FIG. 2 is a front end elevation, partially broken away;

FIG. 3 is a plan view of the conductive rubber sheet bearing the buttons;

FIG. 4 is a plan view of the printed circuit board;

FIG. 5 is an exploded sectional view along line 5—5 of FIG. 1;

FIG. 6 is a plan view of a digital coding device made in accordance with this invention;

FIG. 7 is a front elevation of FIG. 6;

FIG. 8 is a plan view of the insulating separator mask;

FIG. 9 is a plan view of the printed circuit board;

FIG. 10 is a plan view of the printed circuit board with "strobe;"

FIG. 11 is a plan view of the insulating separator mask for use with board of FIG. 10;

FIG. 12 is a vertical cross-sectional view of another switch similar to that of FIGS. 1-5;

FIG. 13 is a graph produced by the testing of the switch shown in FIG. 12;

FIG. 14 shows a keyboard switch unit with an alternative cover element;

FIG. 14a is a cross section of a portion of the keyboard unit of FIG. 14;

FIG. 15 is an exploded view, partially broken away, of a keyboard unit similar to the preceding Figures but with a different cover;

FIG. 16 is a cross section similar to FIG. 14 but including still a different cover element;

FIGS. 17 and 18 are plan and cross section views of another embodiment of the invention;

FIG. 19 is a plan view, partially broken away, of a further embodiment of the invention;

FIG. 20 is a cross sectional view taken on the line 20—20 of FIG. 19; and

FIG. 21 is a plan view of still a further embodiment.

SPECIFIC EXAMPLES OF INVENTION

A specific example of this invention is illustrated in FIGS. 1 to 5 which illustrate an uncoded, simple decimal keyboard assembly made in accordance with the present invention. However, as can be readily seen, this invention is also adapted to coded keyboards.

The keyboard assembly 11 comprises in combination a bezel plate 20 having a plurality of openings 21, an electrically conductive silicone rubber sheet 30 co-extensive with the bezel plate 20 and having a plurality of protrusions 31 each covered with an insulating button shell 32 and registerable with the openings 21, a thin insulating separator mask 40 co-extensive with the bezel plate and rubber sheet and having a plurality of openings 41 registerable with the protrusions 31, and a printed circuit board 50 having a plurality of pairs of contacts 51 and 52 registerable with said openings 41. The protrusions or buttons 31 are not an essential part of the invention and may be eliminated, such that pressure is applied to the flat sheet 30 surface directly.

Pressure by the operator on a selected button 32, in this case 6, causes the protrusion 31 to extend through the openings 41 in the mask and contact the pair of contacts 51 and 52 of the 6 circuit, providing an electrical connection between them. Release of pressure on the button 32 permits the resilience of the rubber to cause the button and protrusion to rise without electrical bounce, breaking the circuit connection between 51 and 52. Similarly, pressure on selected button 101, in this case 0 causes the corresponding protrusion to extend through the mask opening and contact both or either of pairs 151/152 and 251/252 providing electrical connection for the 0 circuits.

The printed circuit board 50 can be readily changed for some other printed circuit board with different coding, using the same bezel plate, rubber sheet and separator mask. Thus, a device utilizing such a keyboard can be extremely versatile and provide a great variety of flexible coding at a minimum of expense.

Referring now to the embodiment illustrated in FIGS. 6 to 9, there is illustrated therein a digital coding assembly 111 comprising in combination a resilient conductive polymeric silicone rubber sheet 130 having spaced buttons 131-135 for the numerals 1 to 5. Below the conductive sheet 130 is a co-extensive thin insulating separator mask 140 having apertures 201, 202, 203,

204 and the pair of apertures 205 and 206 arranged to be actuable by pressure on the buttons 131-135 having corresponding digital indicia 1, 2, 3, 4, or 5. Below the mask 140 is a co-extensive printed circuit board 150.

Board 150 has on its upper surface a printed common circuit element 160 in the form of parallel closely spaced branches and having a terminal 160a. Interlaced among the branches of the common electrical circuit element 160 are separate individual circuit elements 161, 162 and 163, each having its own separate terminal. Accordingly, pressure on the selected digital area of the conductive sheet directly or by use of the mounted key protrusion will cause selected and coded contacts between the common circuit element 160 and the individual circuit elements. Release of pressure permits the resilience of the conductive sheet to rise without electrical bounce, thus breaking the particular circuit connection.

Such a digital system can be used as a keyboard for feeding manual data into a digital data processing system. This coding method has an advantage over other coding systems in that the printed circuit board requires no connections through the board but has all its connections on the same surface as the conductive elements printed thereon. Further, by using such an interlaced system, different coding may be readily obtained, simply by changing the aperture pattern in the mask. The mask may be a separate self-supporting sheet of insulating material or may be formed as a thin film deposited on the surface of the board, for example, by silk screen or photoresist technique.

In the variation illustrated in FIGS. 10 and 11 an additional circuit element is interlaced with an additional branch 160b of the common circuit element 160. The mask 140 is correspondingly provided with a line of additional apertures 207-211 arranged above element 170. Thus, operation of any key will both connect the particular data elements (161, 162, 163) to the common element 160 but also connect the latter to the additional element 170. Element 170 thus can operate as a "strobe," to inform a receiving system that there is correct input data available and thus actuate the receiving apparatus to receive the input.

It is generally desirable that closure of the "strobe" contacts be delayed with respect to the closure of the input data circuits so as to assure that the selected data circuits are already properly closed at the time the "strobe" circuit is closed. Such a delay is provided, as shown in FIG. 10, by having the strobe apertures 207-211 narrower than the unit minimal width used for the data circuit apertures, requiring proportionately greater force on the resilient member to accomplish the strobe closure.

In many switching applications, such as keyboards and code generators, particularly including digital circuitry, the transient voltages which are usually produced upon initial closing of conventional switch contacts may have undesirable effects, and these are avoided according to the present invention, as mentioned previously, by use of elastomer filled with conductive particles, and in most instances with nonmetallic conductive particles which provide connecting paths of limited conductivity. To explain more fully, in such digital circuitry, the voltage input to the circuitry must reach a certain "threshold" value before effective

switching action occurs. In a conventional low resistivity switch, the switch resistance drops rapidly and erratically, producing voltage transients which may exceed the threshold value more than once after a single depression of a key, resulting in multiple triggering of the circuitry and causing entry of a particular number where only one entry was intended.

According to the present invention, the production of voltage transients capable of causing multiple entry may be uniquely avoided by the use of an elastomeric material containing a distribution of nonmetallic conductive particles such as carbon or other semi-conductor.

The choice of such semi-conducting particulate material can result in a homogeneous semi-conducting sheet, having volume resistivity in the range of 1 ohm-cm to 10^4 ohm-cm. As noted previously, typically, a commercially available carbon filled silicone or fluoro-silicone elastomer has the following properties:

Electrical Resistivity	7 ohm-cm
Tensile Strength	750 psi
Elongation	200% to 300%
Hardness	58 (Shore A)

With this resistivity, as applied to solid state logic devices, the usual initial voltage transients occur in a voltage range well below the usual threshold switching value of digital circuitry, and consequently cannot cause erroneous results.

Following the above teachings an embodiment was prepared according to FIG. 12 (similar to FIGS. 1-5) having a homogeneous elastomeric conductive sheet 30 of 0.030 inch uniform thickness, an insulator sheet 40 of 0.003 inch thickness with circular apertures 41 of 0.500 inches and an external button cover 32a of 0.125 inch thickness together with a printed circuit board 50 in which the circuits stand approximately 0.001 of an inch above the top of the board. The conductive elastomeric sheet was made of carbon-filled silicone rubber of 7 ohm-centimeters resistivity. The button cover 32a was made of non-conductive silicone rubber. The contacting surface of the conductive elastomeric sheet had a lubricating film of graphite. The graph, FIG. 13, shows the resulting curve of switch resistance in ohms versus force applied perpendicularly in ounces. The change of switch resistance as a function of applied pressure is shown to be a smoothly decreasing function, as the resistance comparable to the threshold resistance is approached with increasing actuating force. Such voltage transients as occur upon initial switch contact are of low amplitude because the semi-conductive sheet resistance is still high. Multiple triggering and hence multiple switching action thus does not occur.

Referring now to the embodiments of FIGS. 14 and 14a; FIGS. 15; and FIG. 16, where like elements are identified by like members, in this embodiment, a keyboard unit for use, for example, in a small portable calculator, has a base 212 carrying on it a multiplicity of contact groups such as are shown at 214 and 216 arranged in a common plane. Such contacts may be printed on base 212 if desired. An insulating spacing element in the form of a planar mask 218 is placed adjacent and parallel to base 212, in contact therewith and provides openings 220 so positioned as to register with selected areas of the contact groups. Above mask

218 in contact therewith and parallel thereto is placed a carbonfilled elastomeric connecting member 222, which is, in this embodiment, about 0.030 inch thick.

In the embodiment of FIG. 15 above connecting member 222 is a thin insulating sheet 224, and above sheet 224 is a cover 228, providing side portions 230 for sealing around the other elements of unit 210 to provide a durable sealed unit. Numbers or other symbols, as at 232, may be printed or otherwise provided on, for instance, the interior surface of transparent cover 228 at locations corresponding to openings 220 in mask 218 and thus to specific connections between contact groups on base 212. Such symbols 232, and openings 220, typically are separated center-to-center by about three-fourths inch, and preferably have an area about that of a one-half inch diameter circle.

For obtaining good contact between member 222 and contacts 214 and 216, it is preferable to manufacture member 222 with a matte, rather than a smooth surface. Such a surface is somewhat porous. A conductive lubricating agent, comprising a fine graphite powder, is rubbed into the matte surface, and the excess powder is removed before assembly of the unit; the resulting surface provides excellent, non-stick connecting action for the switch upon the printed circuit contact elements.

In assembling unit 210, the several layers are sealed together by a suitable adhesive 233 near their outer edges, and at selected portions interior to the outer edges. Side members 230 of cover 228 are then sealed by further adhesive 233 against the abutting edges of all the contained layers, providing a durable, sealed construction that remains substantially free of contaminants, dirt, liquid, and the like.

Since the total travel of connecting member 222 through an opening 120 in mask 118, in order to form a bridging connection between circuit elements on base 212, may be of the order of 0.005 inch or less depending upon thickness of the mask 220 selected, very little motion of cover 228 is felt by the user of the keyboard unit 210 when he depresses an indicated key area such as 232. In some instances this is highly desirable. In other instances, depending e.g., on prior training of the user, while good contact is actually made, the user may feel uncertain about whether the switching action has occurred. A solution to this problem is a switching keyboard unit such as unit 210 with a cover 234 of another type, shown in FIGS. 14 and 14a.

Cover 234 is thin-walled and generally hollow, and composed, in this embodiment, of a soft molded elastomer. Insulating sheet 224 may be omitted when this cover is used. Upraised buttons for the switches are provided, as at 236, in the form of a hollow raised portion. Top button wall 238 is thicker than the remainder of cover 234 and provides a pressure surface 240. Thus, when the user depresses button 238 (FIG. 14), first the button elastically deforms and only after a predetermined travel does pressure surface 240 push connecting member 222 down to provide bridging contact across circuit elements 214 and 216 in the same manner as in the embodiment of FIG. 15. The cover structure thus provides a subjective "feel" of greater travel and positive switching action than does the cover of FIG. 15.

Various original equipment purchasers desire various degrees of give in the keys. Their needs can be accommodated for instance by varying the wall thickness and durometer of the cover wall or by filling the hollow of the button with various quality resilient foams.

As in the embodiment of FIGS. 1-5, desired confidence of location may be provided by the use of a bezel plate cover 270 (FIG. 16), providing apertures 272 of dimensions to admit the finger of the operator. Insulating sheet 274 lies over connector element 222, and is suitably marked with symbols indicating the key area; these symbols are visible through apertures 272. Plate 270 provides sloping aperture walls 278, which touch the finger of the operator as he pushes a "key," thereby providing a positive feel of location of the key as well as of finger travel to depress the key.

The above embodiments of keyboard units make no provision for lock-out, that is, for preventing the simultaneous depression of two keys. Such provision is generally made in the associated circuitry which is actuated by the switches (but can also be made by additional structure of the keyboard). If two keys are depressed together, according to the invention, it is possible to ensure that the contacts of the two switches are not all shorted through the connecting sheet member and thus avoid difficulties in the associated circuitry.

In the embodiment of FIGS. 17 and 18 the connecting member is in the form of discrete individual connecting units insulatively separated from one another. This keyboard unit 310 has a base 312, carrying circuit elements 314 and 316 to be connected together by the switch. Insulating and spacing member 318 lies above the circuit elements and provides openings 320 registering with portions of the circuit elements. Individual connecting members 322, each composed of a semi-conducting elastomeric sheet material as previously disclosed, and each of size suitable to cover an opening 320 and to extend therebeyond without touching the next member 322, are positioned above the openings, and are secured to insulating member 318 by suitable adhesive 233 around the outer edges of each connecting member 322. A cover 328 is provided as in the previously described embodiments, and the switching action is the same as has been described, i.e., finger pressure presses the portion of the member 322 registered with opening 320, into the opening. This portion of the elastomer is elastically distended downwardly while neighboring portions remain positioned at the original height by the spacing member. Removal of the finger allows the sheet member 322 to regain its original planar form due to elastic restoring forces.

In many applications of detector switches, as for example, on appliance controls, or as a sensor on an elevator door, or as a limit switch controlling other circuits, e.g., to reverse the motion of a machine tool, voltage transients occurring when the switch is first closed cause no difficulty. In such applications, the conducting connecting element may be made of an elastomeric material such as commercially available electrically conductive silicone or fluorosilicone elastomers, filled with finely divided metallic particles, such as silver, providing a homogeneous conducting elastomer of low resistivity, similar to that of a metal.

Such an elastomer when filled with metallic silver particles typically, as mentioned previously, has the following properties:

Electrical Resistivity	0.001 to 0.010 ohm-cm	5
Tensile Strength	250-400 psi	
Elongation	60% to 150%	
Hardness	30 to 60 (Shore A)	

Referring to FIGS. 19 and 20 there is shown a portion of an embodiment which can utilize a typical silver-filled elastomer. This embodiment forms a mat, typically for use in such applications as the opening of doors in a building such as a supermarket, but useful also in widely varied applications including, for instance, burglar alarms. Mat unit 410, in general, includes a base 412 and conductive sheet element 422 with an insulating spacing element 418 therebetween, all parallel to one another. Base 412 supports two sets of circuit contact elements 414 and 416, adjacent to but spaced from one another, in side by side relationship and connected to terminals 414a and 416a. Such circuit elements may be, for example, printed on a flexible sheet which is adhered to base 412, or the entire base may be flexible. Insulating spacing element 418 between circuit elements 414 and 416 and sheet element 422 comprises a sheet form element of e.g., 0.015 inch thickness, defines openings 420, exposing portions of circuit contact elements 414 and 416. Above insulating spacing element 418 in face-to-face contact therewith is a resilient, flexible, electrically conductive elastomeric sheet element 422 filled with metallic particles such as silver, as previously described. Although insulating spacing element 418 is shown here in integral form, in other embodiments it may advantageously be formed as separate pieces of material cooperating to define openings 420; such separate elements may be joined to the lower surface of the conductive sheet element 422, or to the base 412 and contacts 414 and 416. Alternatively, in some embodiments insulating elements may be provided in the form of a material such as varnish, applied to areas of conductive sheet element 422 or to areas of base 412 and contacts 414 and 416. In all cases, openings 420 are provided for defining possible areas of electrical contact between sheet element 422 and contacts 414 and 416, and must be of such height as to perform its spacing function when activating force is not applied. Insulating elements 418 must be sufficiently thin that, when a force is applied as indicated at arrow 424, to sheet element 422, element 422 is elastically deformed in region 426 into opening 420 in a generally curved shape, convex toward circuit elements 414 and 416, and as increasing downward force is applied, an increasing area of sheet 422 moves through opening 420 and comes into contact with circuit elements 414 and 416, providing bridging electric contact between them. Since sheet 422 is elastomeric, and its portions about the opening 420 are retained at a position spaced from the contact elements, when the applied force is removed, the elastically deformed region 426 returns to its normally planar condition, above opening 420 and spaced from circuit elements 414 and 416. As an example for this application the separation 418 may be .015 inch thick, the elastomer sheet 422, .030 inch, the above foam 428, 0.125 inch thick and the outer skin 430 (either e.g., mylar (duPont Trademark) or rubber coated metal) 0.015 inch thick.

The switching connection between circuit elements 414 and 416 may be used in any convenient way to accomplish the intended function, as for instance, to cause a door to open in response to the pressure of a foot on the mat. An insulating cover 427 is provided over connecting member 422, and in this embodiment is made of a soft (about 25 durometer) rubber 428, on top of which is a relatively stiff outer member 430. Local pressure even on a very small region on the stiff outer member, is spread over a relatively large area by the stiff member, compressing the low density foam which in turn presses the sheet 422 into the openings 420, as just described.

Referring to FIG. 21 this switch is of an extremely elongated form, length 1 being as great as ten feet or more, with a large multiplicity of openings 420 of the spacer distributed over its entire area. In this form it is usable as on under-the-rug burglar alarm, employing a thin flexible base, providing an over-all switch thickness of less than as little as one-quarter inch with over-all flexibility sufficient to permit it to be coiled into a package for handling and shipment.

In light of this disclosure other embodiments will be understood to be encompassed by the various aspects of the invention.

I claim:

1. An electric switch comprising in combination at least one pair of contact elements and resilient, flexible, electrically conductive sheet means of an elastomer having electrically conductive particles distributed therethrough, said sheet means spaced adjacent but apart from said elements so that pressure applied against said sheet means will cause it to connect said elements thus providing a bridging conductive path through the particle-containing elastomer, and release of pressure will cause said sheet means to disconnect from said elements and open the path between the elements.

2. The switch of claim 1 wherein said elastomer is carbon filled.

3. The switch of claim 1 wherein said sheet means has substantially the electrical resistance of carbon filled silicone and fluorosilicone elastomers.

4. An electric switch for producing a signal for use by solid state electronic digital logic circuitry, said switch comprising at least one pair of contact elements and a resilient, movable electrically conductive bridge means made of elastomer with conductive particles distributed therethrough, said bridge means spaced adjacent but apart from said elements so that motion of said bridge means against said elements will cause said elements to be connected conductively through the particle-containing elastomer to provide a bridging conductive path and reverse movement of said bridge means will cause said bridge means to disconnect from said elements and open the path between the elements, the switch enabling production of a signal without electrical bounce effects.

5. The switch of claim 4 wherein said particles are of nonmetallic conductive material, limiting the conductivity of said path.

6. The switch of claim 5 wherein said particles comprise carbon filler in said elastomer.

7. The switch of claim 4 wherein said elements comprise printed circuits secured to a printed circuit board, and non-moving portions of elastomer integral with

said bridge means are supported by said board in an insulated condition relative to said printed circuits, said portions retaining said bridge means in said spaced position in the absence of pressure applied against said bridge means.

8. The switch of claim 4 wherein neighboring portions of elastomer integral with said bridge means extend to various sides of said bridge means and, together with said bridge means comprising a sheet means, the direction of movement of said bridge means being normal to the direction of extent of the sheet means and the conductivity path between said contact elements being in the direction of said extent.

9. The switch of claim 8 wherein the elastomer portion defining said bridge means is sized for deflection by a finger of the human hand.

10. An electric switch comprising in combination contact means, resilient, flexible electrically conductive sheet means of electrically conductive elastomer and positioning means positioning said sheet means so that a first portion of said sheet means is adjacent but apart from said contact means, and said first portion free to move relative to neighboring portions of said sheet means whereby pressure applied against said first portion will cause it to connect to said contact means conductively, and release of said pressure will cause said portion of said sheet means to disconnect from said contact means.

11. The electric switch of claim 10 wherein said neighboring portions support said first portion in said spaced apart position in the absence of external operating pressure.

12. The electric switch of claim 10 wherein there are a plurality of electrical contact elements, said sheet means including a plurality of sheet portions positioned over respective electrical contact elements, said respective portions being free to move and press against respective contact elements in response to pressure applied to said portions.

13. The electric switch of claim 12 wherein said contact elements comprise part of a printed circuit.

14. The switch of claim 12 useful as a detector wherein said contact elements when connected by said sheet means all complete the same circuit to a pair of terminals whereby pressure at any of said portions of said sheet means can complete the same circuit.

15. The switch of claim 10 adapted for manual pressure on said portion, said portion being covered by an insulating layer.

16. The switch of claim 15 wherein said insulating layer is in the form of a button accessible to the finger.

17. The switch of claim 16 wherein said insulating layer comprises an elastomer forming a button shape, said button shape being resiliently deformable, providing for travel of the finger between the time of contact with such button and the time the button is deformed against said sheet means sufficient to apply actuating pressure.

18. The switch of claim 17 wherein said button is a hollow, thin-walled member.

19. The switch of claim 15 including an outer member having an opening exposing to the finger said insulating layer for application of actuating pressure to said portion.

20. An electric switch assembly comprising in combination a non-conductive base carrying a printed circuit means which defines circuit contact elements at a spaced plurality of locations; portions of electrically conductive, resilient elastomer; means positioning elastomer portions adjacent but apart from respective contact elements; the respective elastomer portions being free to move and press against the respective contact elements in response to pressure applied to said portions, said switch adapted for actuation by externally applied pressure on said portions, said portions associated with outer insulative pressure transmitting means.

21. The electric switch of claim 20 wherein said elastomer portions comprise carbon filled elastomer, so that pressure applied against a said portion will cause it to connect said element with limited conductivity and release of pressure will cause said portion to disconnect from said element.

22. The electric switch of claim 20 wherein said elastomer comprises a homogeneous body of elastomer and electrically conductive particles distributed therethrough.

23. The switch assembly of claim 20 wherein each movable portion of conductive elastomer is integral with neighboring portions of elastomer held so that resilient deflection of said elastomer occurs between said movable and neighboring portions during application of said externally applied pressure, providing a return force upon release of said pressure.

24. An electric switch comprising in combination at least one pair of circuit contact elements and a resilient, flexible, electrically conductive, elastomeric sheet means of electrically conductive silicone elastomer spaced adjacent but apart from said elements so that pressure applied against said sheet means will cause it to connect said elements conductively thus providing a bridging conductive path and release of pressure will cause said sheet means to disconnect from said elements and open the path between the elements.

25. A keyboard assembly comprising in combination resilient, flexible, electrically conductive, elastomeric sheet means, an insulating separator sheet below said conductive sheet means, and an electrical circuit board below said separator sheet and having contact elements; said separator sheet having openings registrable with said elements so that pressure applied against the portion of said conductive sheet means above an opening will cause it to press against a said element causing it to connect to said element conductively, and release of said pressure will cause said sheet means to disconnect from said element.

26. A keyboard assembly comprising in combination resilient, flexible, electrically conductive, elastomeric sheet means, an insulating separator sheet below said conductive sheet means, and an electrical circuit board below said separator sheet and having a plurality of pairs of spaced contact elements; said separator sheet having openings registrable with said pairs of elements so that pressure applied against the portion of said conductive sheet means above an opening will cause it to press against the pair of contact elements causing it to connect said elements conductively thus providing a bridging conductive path, and release of said pressure will cause said conductive portion to disconnect from said elements and open the path between the elements.

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27. The keyboard assembly of claim 26 wherein said conductive sheet means is provided on its outer surface with an insulating layer at least in the area of said openings.

28. The keyboard assembly of claim 26 wherein said conductive means is provided on its outer surface with buttons registrable with said openings.

29. A digital coding assembly comprising in combination a resilient, flexible, electrically conductive elastomeric sheet means, an insulating separator layer below said sheet means and having a selected pattern of apertures and an electrical circuit board below said layer and having on its upper surface a common circuit element interlaced with a plurality of individual circuit elements, pressure applied against the portion of the conductive sheet means above the pattern of apertures causing that portion to provide a bridging conductive path from the common circuit element to each circuit

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element exposed by the apertures and release of said pressure causing opening of said path.

30. The device of claim 29, wherein the conducting pattern for all said circuit elements is on said upper surface.

31. The device of claim 29 wherein said common circuit element comprises a series of parallel branches with each said individual circuit element being disposed between a different pair of said branches.

32. The device of claim 29 wherein all apertures are arranged so that one special circuit element is always connected to the common element by depression of the conductive sheet means at any actuation point.

33. The device of claim 32 wherein apertures which provide contact with said special element are smaller than the unit aperture for the other circuit elements, thus providing for a delayed action.

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