United States Patent

Wiedmer

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[54] PUSHBUTTON KEYBOARD SWITCH ARRAY AND ASSOCIATED PRINTED CIRCUIT LOGIC CARDS

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[21] Appl. No.: **54,300**

[52] **U.S. Cl.**.....**200/1 R**, 200/5 R, 200/159 R

[51] **Int. Cl.**.....**H01h 9/26**, H01h 13/52

[58] **Field of Search**.....200/1 R, 5 R, 5 E, 16 A, 83 R, 200/86 R, 159 B; 317/101 CE

[56] **References Cited**

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3,120,584	2/1964	Grunfelder et al.	200/5 E
3,350,518	10/1967	Krakinowski et al.	200/83 R
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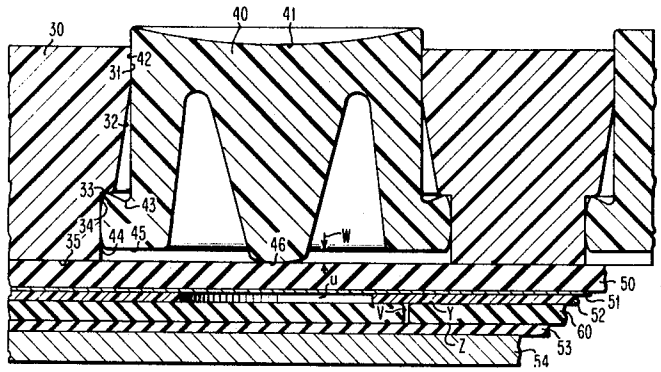
[57] **ABSTRACT**

In a keyboard, an elastic diaphragm switch array and logic, including strobe and rollover protection. The switch includes a diaphragm, a separator, and a switch card. The diaphragm comprises a gold plated continuous sheet of thin spring material and serves as a ground or voltage plane. The switch card has a gold plated pie pattern or switch array at each key location, with generally as many pie sections as there are bits in the code to be produced. Each pie section is wired directly by double sided wiring and through-holes in the switch card to the appropriate output code pin. No decoding or encoding logic is required to produce the code. Strobe logic is provided for assuring that all pie sections have made contact with the diaphragm and rollover protection logic is provided for assuring that only one key is depressed. A key button is provided for pressing the diaphragm through the separator to make contact with the switch card pie pattern.

12 Claims, 8 Drawing Figures



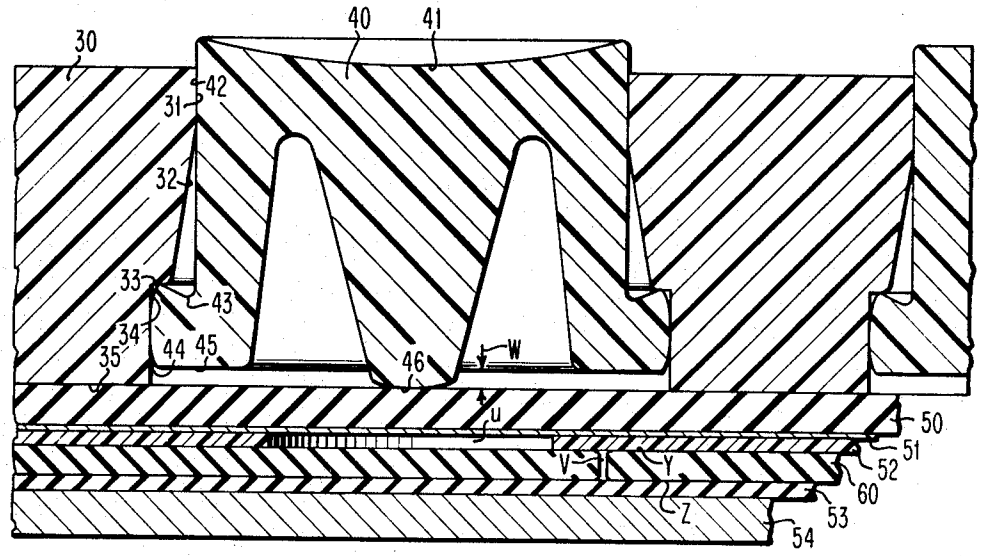


FIG. 1

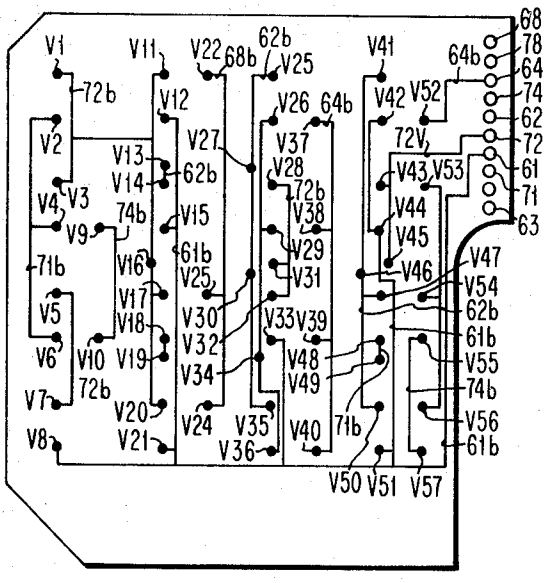


FIG. 2B

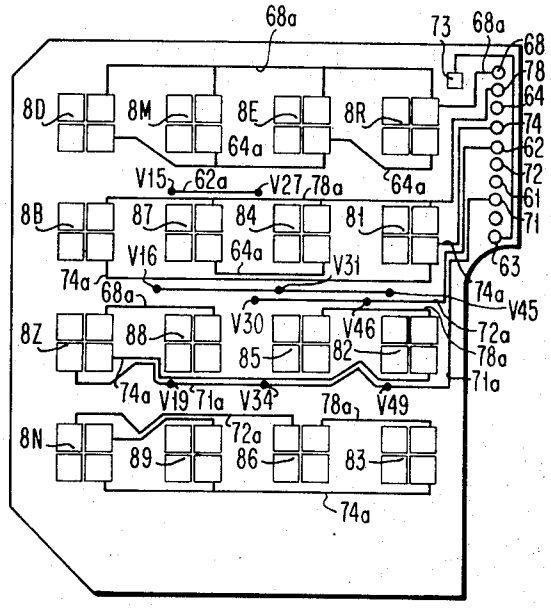


FIG. 2A

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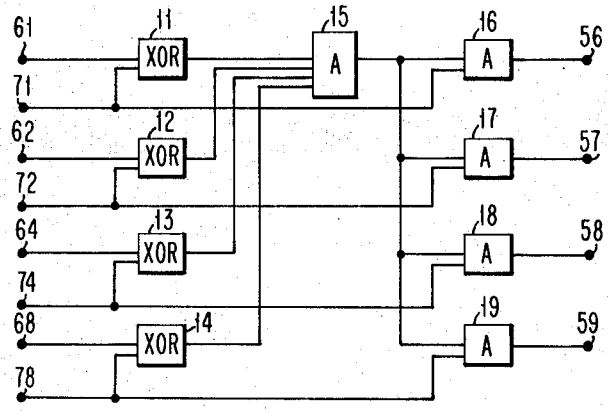
FIG. 2C


61
71
62
72
64
74
68
78
11
12
13
14
XOR
15
16
17
18
19
A
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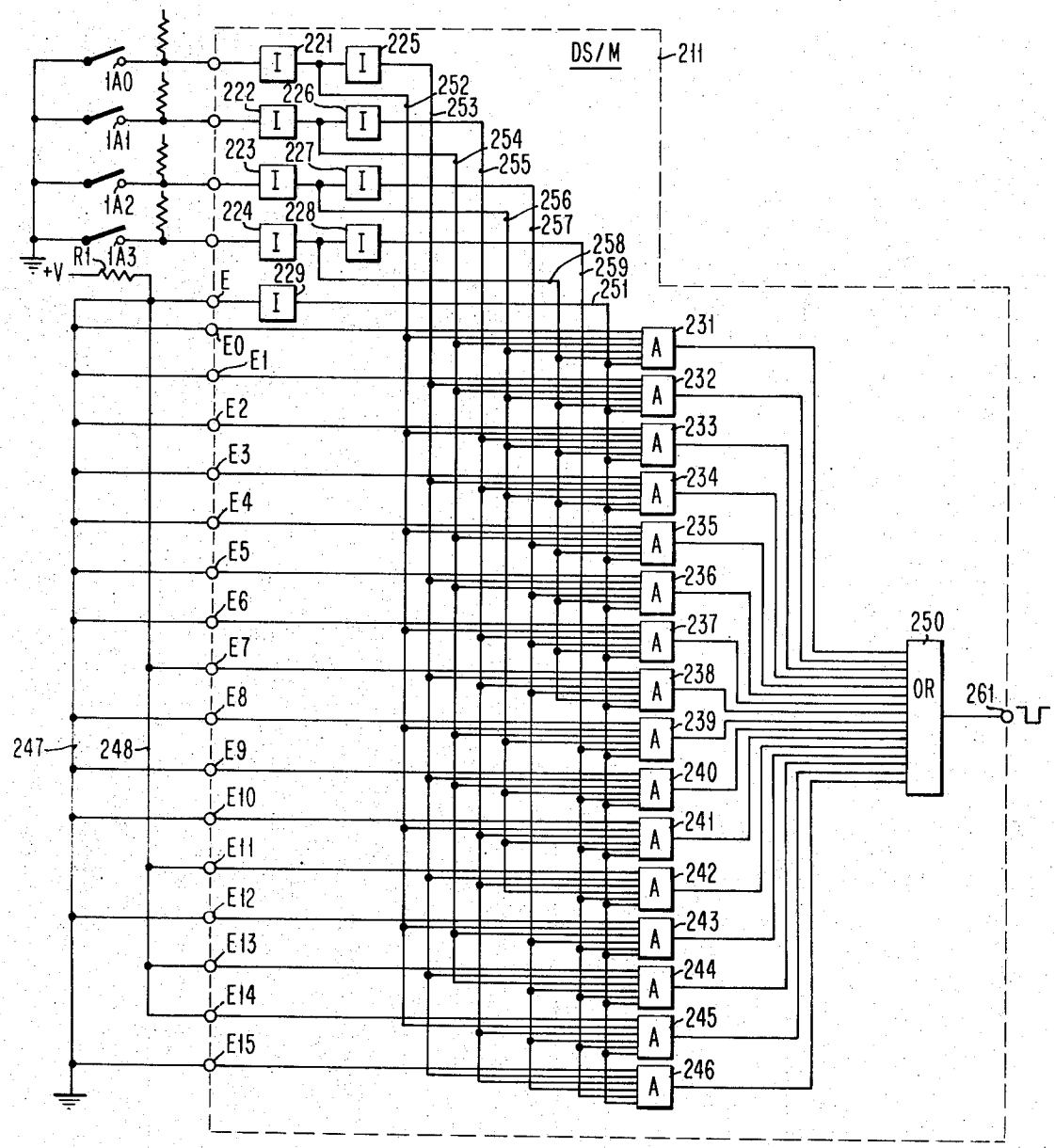
57
58
59


1A0
1A1
1A2
1A3
R1
+V
E
E0
E1
E2
E3
E4
E5
E6
E7
E8
E9
E10
E11
E12
E13
E14
E15
247
248
I
221
222
223
224
225
226
227
228
229
252
253
254
255
256
257
258
259
251
DS/M
211
231
232
233
234
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237
238
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240
241
242
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244
245
246
250
OR
261

FIG. 4C

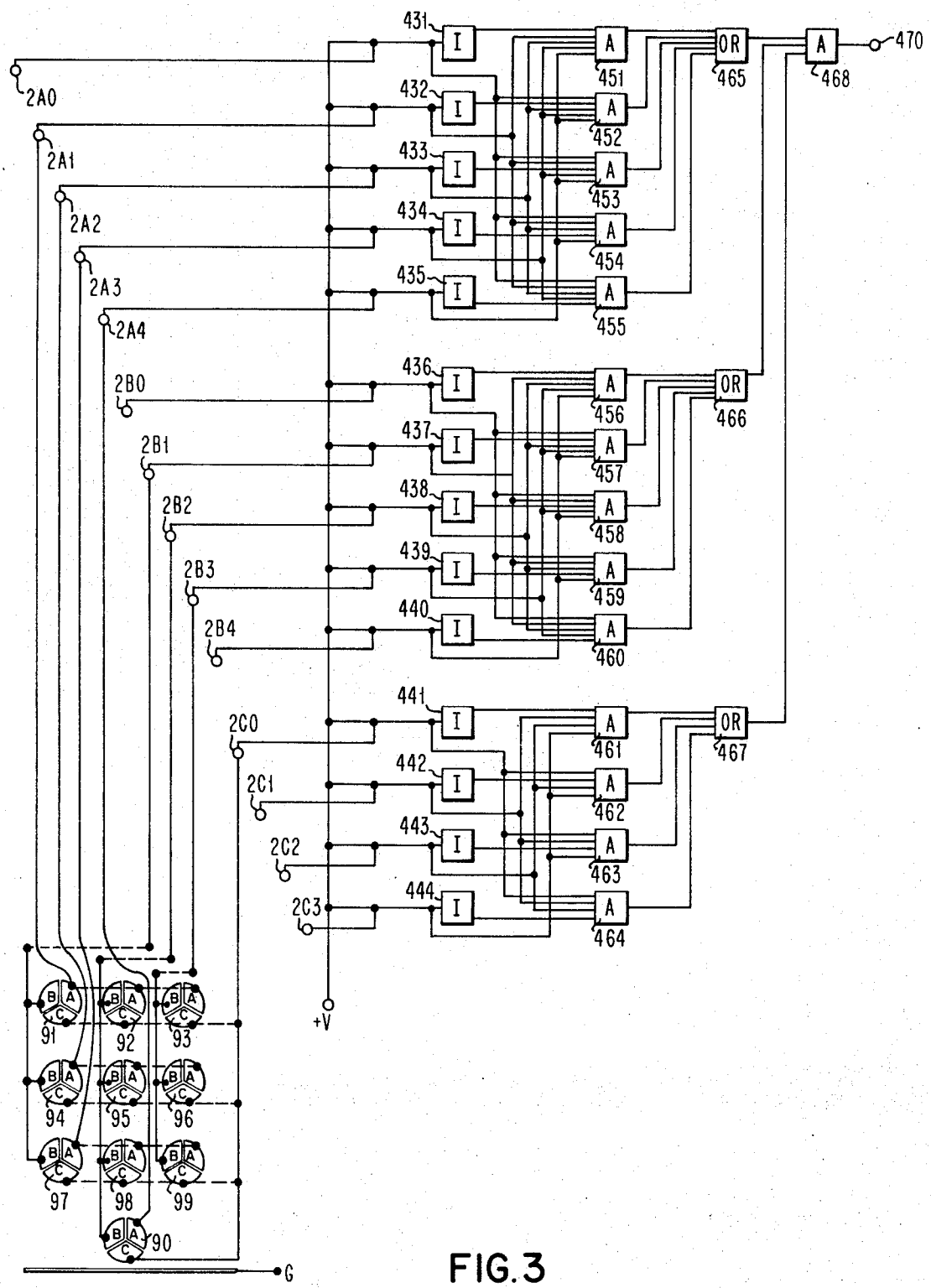
2A0
2A1
2A2
2A3
2A4
2B0
2B1
2B2
2B3
2B4
2C0
2C1
2C2
2C3
431
432
433
434
435
436
437
438
439
440
441
442
443
444
I
A
OR
451
452
453
454
455
456
457
458
459
460
461
462
463
464
465
466
467
468
470
+V
G
90
91
92
93
94
95
96
97
98
99

FIG.3

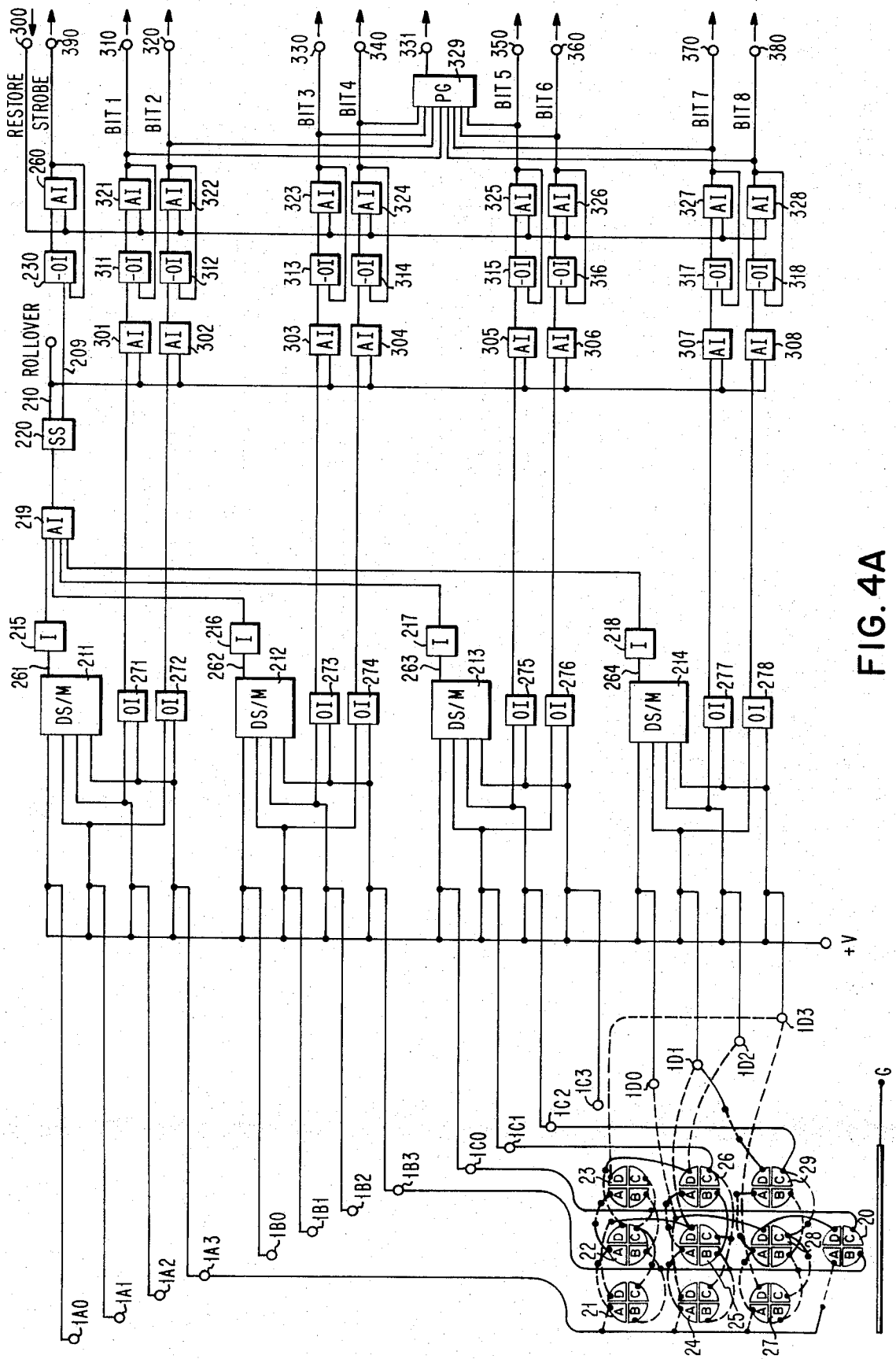
RESTORE
STROBE
BIT 1
BIT 2
BIT 3
BIT 4
PG
BIT 5
BIT 6
BIT 7
BIT 8
ROLLOVER
SS
DS/M
AI
OI
I
+V
G

FIG. 4A

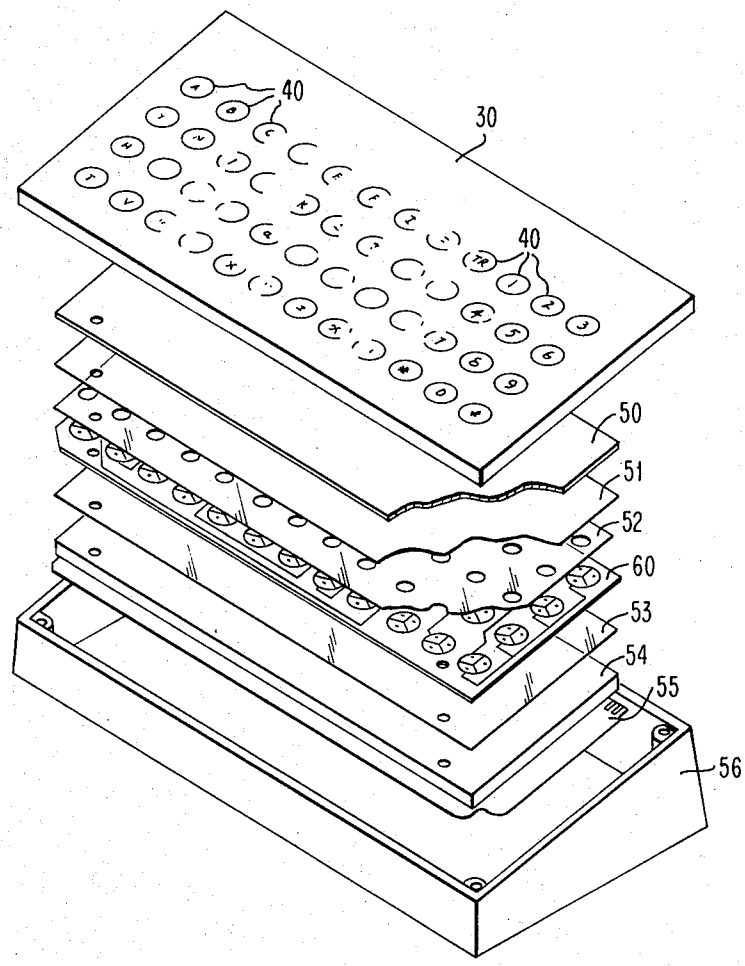

FIG. 5

PUSHBUTTON KEYBOARD SWITCH ARRAY AND ASSOCIATED PRINTED CIRCUIT LOGIC CARDS

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to electrical switching elements for generating an output code, and more particularly to an array of pressure-sensitive elastic diaphragm switching elements which are double sided wired on a switch card to output pins and thence to strobe and rollover protection logic.

2. Description of the Prior Art

U.S. Pat. No. 3,308,253 by M. Krakinowski, and of common assignee, describes a diaphragm switch having a diaphragm supported on an incompressible layer and an elastomer overlaying the diaphragm. When pressure is applied to the elastomeric material, the elastomeric material and the diaphragm are deformed to bring the terminals into contact with each other. In Krakinowski, at least two embodiments are shown: the first being one in which strips of conducting materials are oriented perpendicular to each other and the switching points oriented in the matrix array, and a second embodiment where the array is constructed by coating the entire underside of the diaphragm 18 with conducting material or using a diaphragm of conducting material and providing an individual conducting segment for each index position. In the latter embodiment, a single lead is connected to the conducting layer under the diaphragm and an individual output lead is provided for each of the segments. Thus, in Krakinowski, each key or index position must be determined by decoding the XY coordinates or the single lead. It then becomes necessary, in the event that an output code is desired, to provide logic for decoding the index point for the given XY coordinate.

Another prior art keyboard provides a binary encoding device including a key which selectively interconnects multiple electrical conductors or circuits which are printed or otherwise arranged in parallel on a flat base member. Each key includes plurality of metallic circuit closing or shunting bars having variously spaced projecting contact members thereon which, when actuated selectively draw current through one or more of the parallel electrical conductors. One severe limitation on the usefulness of this prior art device is the number of different output pins which may be utilized; that is, a conductive line for each output pin must pass beneath each key position. And yet, they must not be spaced so closely that the shunting bars cannot make distinct contact with individual conductive lines.

SUMMARY OF THE INVENTION

It is therefore an object of the invention to provide an improved pressure responsive electrical switching element.

A more specific object of this invention is to provide an improved diaphragm, pressure-responsive switching element.

It is a further object of the invention to provide an improved pressure-responsive diaphragm switch having a plurality of switching elements or pie sections which are double wired to output pins for producing an output code directly without decoding or encoding logic.

It is a further object of the invention to provide an improved elastic diaphragm switch keyboard with strobe logic for assuring that all pie sections have made contact with the diaphragm.

It is a further object of the invention to provide an improved elastic diaphragm keyboard having rollover protection logic for assuring that only one key is depressed when transmitting the output code.

The above objects are achieved by the invention which provides an electronic switch means comprising at least one key button, an elastic diaphragm means, separator means, and a switch card means. The switch card comprises a substrate and at least one array of switching elements or pie sections. A plurality of the switching elements or pie sections are electrically connected by double sided wiring on the substrate to the output pins. The elastic diaphragm comprises a thin continuous sheet of conductive and spring material which may be deflected by the key button through the separator into electrical contact with the array of switching elements or pie sections. Double sided wiring connects the pie sections to the output pin for generation directly of the output code from the switching array. Detection of simultaneous electrical contract between said diaphragm and a plurality of switching elements of different arrays is provided by rollover protection logic. Similarly, detection of electrical contact between said diaphragm and all of the switching elements of an array is provided by strobe logic means.

The foregoing and other objects, features and advantages of the invention will be apparent from the following more particular description of preferred embodiments of the invention as illustrated in the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cross-section view of the key button, the elastic diaphragm, the separator and the switch card for use in the keyboard of the invention.

FIG. 2A shows the pattern of pie sections and conductors on the top side of a switch card; and

FIG. 2B shows the pattern of conductors on the bottom side. The dark dots shown on the conductive land patterns represent thru holes for connecting the top and bottom conductors.

FIG. 2C is a logic diaphragm of the circuitry required for rollover protection and strobing of the code generated at the output pins of FIGS. 2A and 2B.

FIG. 3 shows the switch card array for a ten key keyboard utilizing a 3 out of 14 code and the associated logic for strobe and rollover protection.

FIG. 4A shows the switch card array for a 10 key keyboard and associated rollover protection and strobe logic for generating an EBCDIC code.

FIG. 4C describes in greater detail the Data Selector/Multiplexer (DS/M) of FIG. 4A.

FIG. 5 is a perspective view of a console and its internal parts illustrating the structural layout of a keyboard.

ELASTIC DIAPHRAGM SWITCH KEY CONSTRUCTION

Referring now to FIGS. 1 and 5, a description will be given of the elastic diaphragm switch key including the button 40, diaphragm 51, and switch card or base 60.

FIG. 5 illustrates a plurality of buttons 40 in a keyboard console array and their relationship, in perspective view, to the various layers 50–54, and 60 shown in sectional view in FIG. 1.

Key button (or actuator means) 40 is a round button shown in cross-section through the center line in FIG. 1. Finger area 41 of the button is shown concave but may also be convex, flat, sunk into the face plate 30, flush with or raised above the face plate 30. Face plate 30, layers 50–54 and 60, logic card 55, are mounted as by screws (not shown) in base 56. The outside diameter or gliding surface 42 of button 40 rides within the hole 31 in face plate 30. Hole 31 further includes a cone area 32, a ledge area 33, and a larger diameter surface 34. Cone area 32 serves to reduce the area of contact between the hole 31 and the button 40, ledge 33 prevents the button 40 from moving upwards out of hole 31.

Button 40 further includes an annular ball portion 44 having a well portion 43 for catching dirt, etc., that may fall between hole 31 and button surface 42. Annular ball section 44 is in the form of a spherical ball when viewed as shown in FIG. 1 for allowing the button 40 to rotate only around the center of the ball 44 and thus prevent binding of the button 40 between surface 42 and hole surface 31. The bottom surface of annular ball 44 comprises a button actuator stop surface 45 for preventing damage to the elastic diaphragm 51 and for giving the desirable force/displacement curve for the actuator 46.

Actuator 46 extends a distance W beneath the surface of annular stop 45, and in cooperation therewith gives a reliable

or repeatable actuation of the elastic diaphragm independent of the finger force characteristics of the keyboard operator.

Distributor layer **50** has several functions. It protects the elastic diaphragm from hard actuation by actuator **46** directly, and from any rough spots on said actuator. The fact that the travel of actuator **46** into the separator **50** is limited by the stop surface **45** further protects the elastic diaphragm layer **51** from accidental or malicious blows on the button **40**.

The actuator **46** plays a material role in the determination of the force/displacement characteristics. Its length W determines the button stoke and its diameter together with the hardness and thickness of the separator layer **50** determines the button force. Thus, a soft and thick distributor **50** gives a light, long button stroke, and vice versa. In general, the softness and thickness of distributor **50** and the dimension W have to be increased and decreased together. But the precise relative selection allows a light button to have a long stroke, or allows a button of any stroke to be made with a lighter or harder touch. Of course, the shape of actuator **46** (that is, whether it is round or flat on the bottom) also plays a role in the force/displacement characteristics of the button, as do the physical characteristics of the elastic diaphragm area **51** and the separator layer **52**. Finally, another function of the distributor **50** is to produce a force on the diaphragm **51** that spreads from the center (i.e., the center line of button **40**) to the edge and does so over a finite length of the button travel while at the same time increasing the force from the center to the edge.

The feature of a key button **40** of the design shown with a actuator **46** and a distributing ring **45** together with a relatively thick, soft distributor **50** permits repeated, reliable operation of the key. The key further includes a separator layer **52** having an opening V through which the elastic diaphragm **51** is pressed into contact with the array of pie sections (that is, switching elements) on the top surface of switch card **60**. The bottom and top surfaces of switch card **60** have conductive land patterns deposited or otherwise provided thereon and via holes as necessary to interconnect the top and bottom land patterns, as will be described in connection with the preferred embodiments of keyboards to be described hereinafter.

Isolator section **53** isolates the switch card **60** from the back plate **54**. Logic card **55** is shown herein, positioned between plate **54** and base **55**. The various layers **50**, **51**, **52**, **60**, **53**, and **54** may be merely placed upon each other and held together by screws or other mechanical fasteners as will be obvious to those skilled in the art.

Diaphragm **51** comprises, for example, ½ to 1 mil Berylco 25 (a beryllium copper spring alloy) plated with 150 micro inches of gold. Varying the thickness of the Berylco 25 in the copper varies the actuating force of the switch very little. The actuating force is determined by the distributor-actuator combination and the separator thickness.

Separator **52** comprises two to three mils of Mylar, with three mils preferred because it tends to make the switch less sensitive to imperfections in the bottom surface of diaphragm **51**. Together with a quarter inch hole in the separator **52**, the three mils thickness Mylar separator **52** makes a sensitive switch that keeps stresses in the diaphragm **51** low.

Herein, switch card **60** comprises a base of copper clad epoxy board. Isolator **53** comprises, for example, 3 mils Mylar, which is not necessary of course if back plate **54** is non-conductive. Said back plate **54** is optionally provided to re-enforce the switch card **60** against abuse.

Referring now to FIGS. **2A** and **2B**, one preferred embodiment of the invention for an elastic diaphragm switch key board array will be described. FIG. **2A** represents a land pattern on the "Y" side of a switch card (refer to FIG. **1**) which will be contacted by the elastic diaphragm. FIG. **2B** represents a pattern of conductors on the "Z" side of the switch card (refer to FIG. **1**), opposite from the elastic diaphragm. FIGS. **2A** and **2B** are viewed from the same position, such that the output pins **61** through **68** appear in the same orientation in both figures. Each key position is represented in FIG. **2A** by an array of four squares. These are the switching elements or pie sections. The dark lines **68A**, **74A**, etc. represent conductors, and the dark dots **V15**, **V49**, etc. represent via holes connecting the conductors of FIG. **2B** with the conductors or square contacts of FIG. **2A**. The four square key contact areas for each key position are electrically insulated from each other. The upper right-hand square, or pie position **8**, represents the eight bit; the lower right-hand square, or pie position **4**, the four bit; the upper left-hand square, or pie position **2** the two bit; and the lower left-hand square or pie position **1**, the one bit position. The upper right-hand square of each key position is wired to either output pin **68** or **78**. The lower right-hand square of each key position is wired to either output pin **64** or **74**. The upper left-hand square of each key position is wired to either output pin **62** or **72**, and the lower left-hand square of each key position is wired to either output pin **61** or **71**. Output pin **63** is wired to pad **73** which is held in continuous contact with the voltage plane or elastic diaphragm. Table 1 shows the interconnection performed by each via hole V–1 through V–57. The bottom connection column refers to the conductor on the bottom, that is in FIG. **2B**. The top connection column represents the conductor or the square pie section to which the via hole interconnects the related bottom conductor. The top connection column is interpreted as follows: Where the via hole are starred as is V–13, V–16, etc., the top connection is to a conductive line such as **62***a*, **72***a*, **71***a*, etc. The other via holes are connected to one of the pie positions at each key location: for example, V–1 is connected to key position D, pie section **2**; via V–**2** is connected to key position D pie position **1**, and so forth.

TABLE 1

Via Hole Connections, FIG. **2**.

Via Hole	Top Connection (Line or pie section)	Bottom Connection (Line)
V1	8D2	72*b*
V2	8D1	71*b*
V3	8B2	72*b*
V4	8B1	71*b*
V5	8Z2	72*b*
V6	8Z1	71*b*
V7	8N2	72*b*
V8	8N1	61*b*
V9	8B4	74*b*
V10	8Z4	74*b*
V11	8M2	72*b*
V12	8M1	61*b*
V13*	62*a*	62*b*
V14	872	62*b*
V15	871	61*b*
V16*	72*a*	72*b*
V17	882	72*b*
V18	881	71*b*
V19*	71*a*	71*b*
V20	892	72*b*
V21	891	61*b*
V22	8M8	68*b*
V23	888	68*b*
V24	898	68*b*
V25	8E2	62*b*
V26	8E1	71*b*
V27*	62*a*	62*b*
V28	842	72*b*
V29	841	71*b*
V30*	62*a*	62*b*
V31*	72*a*	72*b*
V32	852	72*b*
V33	851	61*b*
V34*	71*a*	71*b*
V35	862	62*b*
V36	861	71*b*
V37	8E4	64*b*
V38	844	64*b*
V39	854	64*b*
V40	864	64*b*
V41	8R2	62*b*
V42	8R1	61*b*
V43	812	72*b*
V44	811	61*b*
V45*	72*a*	72*b*
V46*	62*a*	62*b*
V47	822	62*b*

V48	821	71*b*
V49*	71*a*	71*b*
V50	832	62*b*
V51	831	61*b*
V52	8R4	64*b*
V53	818	78*b*
V54	828	78*b*
V55	824	74*b*
V56	838	78*b*
V57	834	74*b*

Referring further to FIG. 2A and 2B, in connection with Table 2, below, the output code for the key board of FIG. 2 will be explained. A 16-key key board is shown having hexidecimal output values zero through F. The various keys are 8B, 81, 82, 83, 84, 85, 86, 87, 88, 89, 8Z, 8N, 8D, 8M, 8E, 8B. The binary value appearing at the output pins 6Z1–678, is shown in the column entitled Binary Value of Output. Thus, a zero in the 8 column indicates a positive logic on pin 78, a 1 in the 8 column represents a positive logic on pin 68, a zero in the 4 column of the table indicates a positive logic on pin 74, a 1 in the 4 column indicates a positive output on line 64, a zero in the 2 column represents a positive logic level on output pin 72, a 1 in the 2 column represents a positive logic level on pin 62, a zero in the one column represents a positive logic on output pin 71, and a 1 in the one column represents a positive logic on output pin 61.

Thus, by depressing the D key to bring the elastic diaphragm voltage plane into contact with switch array 8D, the hexidecimal output code of zero will be detected as positive logic level on output pins 71, 72, 74, and 78, and negative logic level on output pins 61, 62, 64, and 68. Similarly, by bringing the key array 85 into contact with the voltage plane, a hexidecimal 5 output is detected as a positive logic on output pins 64, 61, 78 and 72.

TABLE 2

Output Code for Keyboard of FIG. 2.

Key	Hexidecimal	Binary Value of Output 8	4	2	1
8B	0	0	0	0	0
81	1	0	0	0	1
82	2	0	0	1	0
83	3	0	0	1	1
84	4	0	1	0	0
85	5	0	1	0	1
86	6	0	1	1	0
87	7	0	1	1	1
88	8	1	0	0	0
89	9	1	0	0	1
8Z	A	1	0	1	0
8N	B	1	0	1	1
8D	C	1	1	0	0
8M	D	1	1	0	1
8E	E	1	1	1	0
8R	F	1	1	1	1

It is thus apparent from the above described embodiment of the invention, that the desired hexidecimal output code is produced directly at the output pins 61 through 78. Proceeding now to FIG. 2C, a description will be given of the circuitry required for rollover protection and strobing. Rollover protection is defined as the detection of the simultaneous depression of two keys. Strobing is defined as the detection of a contact closure occurring at each of the pie positions in a given key array. Referring now to FIG. 2C, the output pins 61 through 78 of FIGS. 2A and 2B are shown. The logic of FIG. 2C may be physically located on logic card 55 (FIG. 5). Output pin 61 is connected to Exclusive OR 11. Output pin 71 is connected to Exclusive OR 11 and AND 16. Output pin 62 is connected to Exclusive OR 12. Output pin 72 is connected to Exclusive OR 12 and AND 17. Output pin 64 is connected to Exclusive OR 13. Output pin 74 is connected to Exclusive OR 13 and to AND 18. Output pin 68 is connected to Exclusive OR 14. Output pin 78 is connected to Exclusive OR 14 and AND 19. The outputs of Exclusive OR's 11 through 14 are connected to AND 15, the output of which is connected to AND's 16 through 19. The inputs to AND 15 are satisfied such that there is a positive logic output therefrom only if the output of each Exclusive OR 11 through 14 is positive. This occurs only when one and only one pin of each the following pairs of outputs pins are positive: 61 and 71, 62 and 72, 64 and 74, and 68 and 78. Thus, a positive output from AND 15 indicates that one and only one key on the key board of FIG. 2A has been depressed. The voltage levels on pins 56–59 are decoded directly to the binary values of Table 2.

Referring now to FIG. 3, the switch card array for a ten key keyboard utilizing a three out of fourteen code and the associated logic for strobe and roll-over protection will be described. The various pie sections A, B, and C for the various switch key locations 90 through 99 are wired by double-sided wiring, described above, to the various output pins 2A0 through 2C3. For sake of simplicity, only the switch arrays 90–99 of the ten key numeric portion of a much larger keyboard is shown, while the logic for the full keyboard is shown. The connections from the various keys 90–99 to the output locations 2A0–2C3 are shown in heavy and dotted lines: the heavy lines being on one side of said switch card and the dotted lines on the other side. It will be apparent to those skilled in the art, that various other wiring schemes may be utilized to connect the various pie sections A, B, and C to the output pins 2A0–2C3. The heavy dots at the connection of dotted lines to solid lines or at the connection of dotted lines to pie sections at the various key locations represent through holes, while the heavy dots between solid lines and the pie sections merely indicate connections between the land pattern conductors and the pie sections which are on the same side of the switch card. Herein, all of the output pin locations 2A0 through 2C3 are connected to positive voltage. The elastic diaphragm is at ground voltage, herein, and is shown as element 50A, diagrammatically.

The roll-over protection logic, as will be described more fully hereinafter, comprises inverters 431 through 444, AND circuits 451 through 464, OR circuits 465 through 467, and AND circuit 468. As will be apparent more fully hereinafter, the 3 of 14 output code generated by actuating one of the keys at key positions 90–99 appears directly at output pins 2A0 to 2C3, while a signal at pin 470 indicates that only one key has been actuated, and that all of the pie sections of that key have made contact with diaphragm 51A, thus signaling that a valid code exists at output pins 2A0–2C3.

First, the output code generated by the various keys 90–99 at output pins 2A0–2C3 will be described, followed by description of the strobe and roll-over protection circuitry of FIG. 3.

First it should be noted that the A pad of each key 90–99 is connected to one and only one of output pins 2A0–2A4. The B pad of each key location 90–99 is connected to one and only one of output pins 2B0–2B4. And finally, the C pad at each key location 90–99 is connected to one and only one of output pins 2C0–2C3. Thus, actuation of key 90 causes a positive logic signal to appear at output pin 2B2, and 2A4, and 2C0. The following Table 3 summarizes the connection between the various pie or switch locations A, B, and C of each key (or switch array) to output pins 2A0–2C3.

TABLE 3

Summary of Connections: Key Locations to Output Pins for FIG. 3

Key Location	Pie Section or Switch Location	Output
90	90A	2A4
	90B	2B2
	90C	2C0
91	91A	2A1
	91B	2B1
	91C	2C0
92	92A	2A1
	92B	2B2
	92C	9C0

93	93A	2A1
	93B	2B3
	93C	2C0
94	94A	2A2
	94B	2B1
	94C	2C0
95	95A	2A2
	95B	2B2
	95C	2C0
96	96A	2A2
	96B	2B3
	96C	2C0
97	97A	2A3
	97B	2B1
	97C	2C0
98	98A	2A3
	98B	2B2
	98C	2C0
99	99A	2A3
	99B	2B3
	99C	2C0

Thus, from Table 3 and FIG. 3, it becomes apparent that actuation of key **90** gives an output code comprising positive logic signals at output pins **2A4, 2B2, 2C0**. Similarly, actuation of key **94** causes an output code to appear in the form of contact closures at pins **2A2, 2B1**, and **2C0**.

Referring again to FIG. 3 the strobe and roll-over protection circuitry will be described. Output pin **2A0** is connected to inverter **431**, and to AND circuits **452** through **455**.

Output pin **2A1** is connected to inverter **432** and AND circuits **451, 453, 454**, and **455**. Outpin pin **2A2** is connected to inverter **453** and to AND circuits **451, 452, 454**, and **455**. Output pin **2A3** is connected to inverter **434** and to AND circuits **451, 452, 453**, and **455**. Output pin **2A4** is connected to inverter **435**, and to AND circuits **451** through **454**.

Output **2B0** is connected to inverter **436**, and to AND circuits **457** through **460**. Output pin **2B1** is connected to inverter **437** and to AND circuits **456, 458, 459**, and **460**. Output pin **2B2** is connected to inverter **438**, and to AND circuits **456, 457, 459**, and **460**. Output pin **2B3** is connected to inverter **439**, and to AND circuits **456, 457, 458**, and **460**. Output **2B4** is connected to inverter **440**, and to AND circuits **456** through **459**.

Output pin **2C0** is connected to inverter **441** and to AND circuits **462** through **464**. Output pin **2C1** is connected to inverter **442** and to AND circuits **461, 463**, and **464**. Output pin **2C2** is connected to inverter **443**, and to AND circuit **461, 462**, and **464**. Output pin **2C3** is connected to inverter **444**, and to AND circuits **461** through **463**.

Inverter **431** is connected to AND circuit **451**, inverter **432** to AND **452**, inverter **433** to AND **453**, inverter **434** to AND **454**, inverter **435** to AND **455**, inverter **463** to AND **456**, inverter **437** to AND **457**, inverter **438** to AND **458**, inverter **439** to AND **459**, inverter **440** to AND **460**, inverter **441** to AND **461**, inverter **442** to AND **462**, inverter **443** to AND **463**, and inverter **444** to AND **464**. The inputs to OR **465** are the outputs of ANDs **451** through **455**, the inputs to OR **466** are the outputs of ANDs **456** through **460**, and the inputs to OR **467** are the outputs of ANDs **461** through **464**. The outputs of OR circuits **465** through **467** are fed to AND circuit **468**, the output of which appears at pin **470**. A signal at pin **470** indicates strobe and no roll-over.

Referring now to FIG. 4A, a description will be given of a keyboard and logic for generating an EBCDIC code wherein each pie position of each key determines two bits in the output code according to the following table:

TABLE 4

Output Code and Wiring for EBCDIC Keyboard of FIG. 4A

Key Position	Output Pin Locations for Pad A B	C	D	Output Code A B C D 12 34 56 78
20	1A3 1B3	1C0	1D0	11 11 00 00
21	1A3 1B3	1C0	1D1	11 11 00 01
22	1A3 1B3	1C0	1D3	11 11 00 10
23	1A3 1B3	1C0	1D3	11 11 00 11
24	1A3 1B3	1C1	1D0	11 11 01 00
25	1A3 1B3	1C1	1D1	11 11 01 01
26	1A3 1B3	1C1	1D2	11 11 01 10
27	1A3 1B3	1C1	1D3	11 11 01 11
28	1A3 1B3	1C2	1D0	11 11 10 00
29	1A3 1B3	1C2	1D1	11 11 10 01

The above table, giving the output code and wiring scheme for the EBCDIC keyboard of FIG. 4A, may be correlated with FIG. 4A in the following manner. Actuation of the key which brings switch array **20** into contact with ground plane or elastic diaphragm **51B** causes a positive logic signal to appear at output pin locations **1A3, 1B3, 1C0**, and **1D0**. This gives an output code of **11110000**. The wiring from key **20** to said output pins is by double-sided wiring, as shown in FIG. 4A, where the switch locations or pie positions and the wiring on the same side of the switchcard as said pie positions are shown in solid lines, with the dark dots representing via holes between said conductors and pie positions to the dotted lines representing conductors on the opposite side of said switch card. Thus, pie section B of switch array **20** is connected by a solid line to output pin **1B3**, pie sections A and D are connected by double sided wiring (shown by dotted and solid lines) to pads **1A3**, and **1D0** and pie section C is connected by single side wiring to its output pin **1C0**.

While actuation of a given key results in direct generation of sixteen bit code at output pins **1A0–1D3**, herein the code at said pins is further decoded to give an eight-bit output code at pins **310, 320, 330, 340, 350, 360, 370**, and **380** of FIG. 4A. The same decoding logic for giving the eight-bit output code is utilized for the strobe and rollover protection in the manner to be described hereinafter. Referring again to the TAble **4** in connection with FIG. 4A, output code bits **1** and **2** are determined by the state of output pins **1A0, 1A1, 1A2**, and **1A3**. Output code bits **3** and **4** are determined by the state of output pins **1B0–1B3**. The bits **5** and **6** of the output code are determined by the state of output pins **1C0–1C3**, and the state of bits **7** and **8** of the output code are determined by the condition of output pins **1D0–1D3**. For each set, that is, the A, B, C, or D set of pins, the associated two bits in the output code will be zero if the zero (i.e., 1A0, 1B0, 1C0, or 1D0) pin is at a positive logic level, or "on." if the **1** pin is on, the associated output code bits will be 01. If the **2** pin is on, the associated output code bits will be 10. And finally, if the **3** output pin is on, the associated output code bits will be 11. In the above manner, output pins **1A0–1A3** on the switchcard control the state of output pins **310** and **320** representing bits **1** and **2**, respectively. Bits 1 and 2 will be 00 if **1A0** pin is on, 01 if **1A1** pin in on, 10 if the **1A2** pin is on, and 11 if the **1A3** pin is on.

As in FIG. 3, FIG. 4A shows the switch array or key locations for only **10** keys of a much larger keyboard, but the logic shown is for the entire keyboard.

Referring now to FIG. 4A, the manner in which the output pins **1A0–1D3** are decoded to provide the rollover protection, strobe, and the eight-bit EBCDIC code will next be described. The Data Selector/Multiplexor, DS/M **211** shown in FIG. 4A is shown in greater detail in FIG. 4B and will be described hereinafter. Suffice it to say at this time, that the outputs of any DS/M will be negative if and only if one of the four inputs is positive. The OR inverters, OI will have a positive output when either but not both of its inputs is positive. An inverter I inverts the signal at the input. An AND inverter AI gives a negative output when all of its inputs are positive. A single shot SS gives a timed positive output whenever its input goes positive. A negative OR inverter -OI gives a negative output when one but not both of its inputs are negative. Parity generator PG gives a positive output when an even number of its inputs are positive, and a negative output when an odd number of its inputs are positive.

Proceeding now with a description of the logic flow of FIG. 4A, output pin **1A0** is connected to DS/M **211**. Output pin **1A1** is connected to DS/M **211** and OI **272**. Output pin **1A2** is connected to DS/M **211** aNd OI **271**. Output pin **1A3** is connected to DS/M **211**, OI **271**, and OI **272**. Output pin **1B0** is connected to DS/M **212**. Output pin **1B1** is connected to

DS/M 212 and OI 274. Output pin 1B2 is connected to DS/M 212 and OI 273. Output pin 1B3 is connected to DS/M 212, OI 273, and OI 274. Output pin 1C0 is connected to DS/M 213. Output pin 1C1 is connected to DS/M 213 and OI 276. Output pin 1C2 is connected to DS/M 213 and OI 275. Output pin 1C3 is connected to DS/M 213, OI 275, and OI 276. Output 1B0 is connected to DS/M 214. Output pin 1D1 is connected to DS/M 214, and OI 278. OUtput pin 1D2 is connected to DS/M 214 and OI 277. Output pin 1D3 is connected to DS/M 214, OI 277, and OI 278.

Herein, all of the output pins 1A0 through 1D3 are connected to positive voltage.

The output of DS/M 211 is inverted by I 215 and fed to AI 219. The output of DS/M 212 is inverted by I 216 and fed to AI 219. The output of DS/M 213 is inverted by I 217 and fed to AI 219. The output of DS/M 214 is inverted by I 218 and fed to AI 219. Thus, a negative output of any DS/M is inverted and appears as a positive input to AI 219. The output of AI 219 will be positive, therefore, when one and only one of the A pins, one and only one of the B pins, one and only one of the C pins, and one and only one of the D pins are at a positive logic level. The output of AI 219 is fed to single shot 220, the output of which appears on rollover protection line 210, which line 210 has a positive logic level when one and only one of the keys 20–29 are in contact with the ground plane or elastic diaphragm 51B.

The output of single shot 220 is also fed bit gates to AI 301–308. The output of OI 271 is fed to AI 301, of OI 272 to AI 302, of OI 273 to AI 303, of OI 274 to AI 304, of OI 275 to 305, of OI 276 to AI 306, of OI 277 to AI 307, and of OI 278 to AI 308. Thus, the various bit gates 301–308 have a positive output when one and only one key has been made as signaled on line 210 and the corresponding bits 1 through 8 has been decoded from the output pins 1A0-1D3 by the OR inverters 271-278. The output of the bit gates, AI's 301-308 are held in the corresponding bit latches, comprising a -OI and an AI, until the latches are restored by a signal at pin 300. Similarly, rollover protection is held in the bit latch comprising -OI 230 and AI 260 to hold output pin 390 at a logic level indicating strobe and inviting the using logic (not shown) to accept the output code appearing on pins 310-380.

Thus, the output of single shot 220 is fed to -OI 230, thence to AI 260, and strobe output pin 390. The output of AI 301 is fed to -OI 311, thence to AI 321 and to bit 1 output pin 310. The output of AI 302 is fed to -OI 312, thence to AI 322 and to bit 2 output pin 320. The output of AI 303 is fed to -OI 313, thence to AI 323 and to bit 3 output pin 330. The output of AI 304 is fed to -OI 314, thence to AI 324 and to bit 4 output pin 340. The output of AI 305 is fed to -OI 315, thence to AI 325 and thence to bit 5 output pin 350. The output of AI 306 is fed to -OI 316, thence to AI 326 and thence to bit 6 output pin 360. The output of AI 307 is fed to -OI 317, thence to AI 327 and thence to bit 7 output pin 370. The output of AI 308 is fed to -OI 318, thence to AI 328 and thence to bit 8 output pin 380. The output of AI's 321–328 are also fed to parity generator 329, the output of which appears at pin 331. The restore line signal appearing at 300 is fed to AI 260, and AI 321-328. The output of AI 260 is fed back to -OI 230. The output of AI 321 is also fed back to -OI 311. The output of AI 322 is also fed back to -OI 312. The output of AI 323 is also fed back to -OI 313. The output of AI 324 is also fed back to -OI 314. The output of AI 325 is also fed back to -OI 315. The output of AI 326 is also fed back to -OI 316. The output of AI 327 is also fed back to -OI 317. And, the output of AI 328 is also fed back to -OI 318.

With the logic above described and shown in FIG. 4A, a signal appearing at output pins 1A0–1D3 representing the closure of contacts comprising the pie sections of a given key location 20–29 and the elastic diaphragm ground plane 51B, are decoded to an eight-bit code at pins 310–380, and roll-over protection and strobe signals are generated at lines 210 and 390.

Referring now to FIG. 4B, a more detailed description will be given of Data Selector/Multiplexor 211 of FIG. 4A. The other DS/M's 212–214 are similarly wired to perform similar functions, as will be apparent to those skilled in the art. Referring now to FIG. 4B, a negative signal appears at output line 261 when one and only one of pins 1A0–1A3 are connected to ground by closure of the corresponding switch. Said switches are shown to represent the pie sections A at the various switch arrays 20–29. Pin 1A0 is connected to inverter 221, pin 1A1 is connected to inverter 222, pin 1A2 is connected to inverter 223, and pin 1A3 is connected to inverter 224. The connections to inverters 221–224 represent the four input lines shown at the inputs to DS/M211 through 214 in FIG. 4A. Not shown in FIG. 4A are the wiring locations E, E0, E15, Wiring locations E7, E11, E13, and E14 are held at a positive voltage through resistance R1. On the other hand, wiring locations E, E0-E6, E8-E10, E12, and E15 are tied to ground.

The ground voltage appearing at wiring location E is inverted by I 229 and fed to AND circuits 231–246. This signal would serve to enable all of said AND circuits 231–246. However, the ground voltage at wiring location E0 is fed to AND 231, thus effectively disabling said AND circuit 231 from operation. Similarly, and for the same function, the ground voltage at wiring location E1 is fed to AND circuit 232, at E2 is fed to A 233, at E3 is fed to AND circuit 234, at E4 is fed to AND circuit 235, at E5 is fed to AND circuit 236, at E6 is fed to AND circuit 237, at E8 is fed to AND circuit 239, at E9 is fed to AND 240, is fed to AND circuit 241, at E12 is fed to AND 243, and at E15 is fed to AND circuit 246. On the other hand, positive voltage at wiring location E7 is fed to AND circuit 238 to enable said AND circuit 238. Similarly, the positive voltage at E11 is fed to AND circuit 242, at E13 is fed to AND circuit 244, and at E14 is fed to AND circuit 245.

The output of inverter 221 is fed along line 252 to AND circuits 231, AND circuit 233, AND circuit 235, AND circuit 237, AND circuit 239, AND circuit 241, AND circuit 246, and AND circuit 245. Also, the output of inverter 221 is fed through inverter 225 and thence along line 253 to AND circuit 232, 234, 236, 238, 240, 242, and 244 and 246.

The output of inverter 222 is fed along line 254 to AND circuits A231, 232, 235, 236, 239, 240, 243, and 244. Also, the output of inverter 222 is fed through inverter 226 along line 255 to AND circuits 233, 234, 237, 238, 241, 242, 245, and 246.

The output of inverter 223 is fed along line 256 to AND circuits 231–234, and 239–242. The output of inverter 223 is also fed through inverter 227 along line 257 to AND circuits 235–238 and 243–246. The output of inverter 224 is fed along line 258 to AND circuits 231–238. Also, the output of inverter 224 is fed through inverter 228 along line 259 to AND circuits 239–246. The output of AND circuits 231–246 are fed to OR circuit 250, the output of which appears at output pin location 261. With the arrangement shown in FIG. 4B, a negative signal will appear at output pin 261 when one and only one of the inputs to inverters 221–224 is positive.

While the invention has been particularly shown and described with reference to preferred embodiments thereof, it will be understood by those skilled in the art that the foregoing and other changes in forms and details may be made therein without departing from the spirit and scope of the invention.

What is claimed is:

1. A keyboard apparatus, comprising:
at least one switch actuator,
an elastic diaphragm, and
a switch card;
said switch card comprising a substrate having a plurality of arrays of switching elements and a plurality of groups of output pins, each said element of a given array being electrically connected by double-sided wiring on said substrate to an output pin in a separate group:
separator means disposed between said elastic diaphragm and said switch card for separating said diaphragm from said switching elements when said actuator is inoperative,

said elastic diaphragm comprising a thin continuous sheet of conductive spring material;

each said switch actuator being actuatable to deflect said diaphragm through said separator into electrical contact with its associated array of said switching elements, whereby an output code is generated at said pins directly from said elements with an output signal present at at least one output pin of each group.

2. The keyboard means of claim 1 further comprising rollover protection logic means responsive to the output code at said pins for detecting simultaneous electrical contact between said diaphragm and a plurality of switching elements of different arrays.

3. The keyboard of claim 1 further comprising strobe logic means responsive to the output code at said pins for detecting electrical contact between said diaphragm and all of the switching elements of an array.

4. In an elastic diaphragm keyboard apparatus, a switch actuator means for moving the elastic diaphragm means into contact with a selected array of switching elements, comprising:

annular stop surface means for controlling the distance of travel of said switch actuator means, and

actuator means integrally coupled to said surface means and disposed along the axis thereof, for causing deflection of said diaphragm,

said diaphragm means being deflected upon actuation of said switch actuator means a distance equal to the protrusion of said actuator means through said stop surface means.

5. The keyboard apparatus of claim 4 further comprising distributor means disposed between said switch actuator means and said diaphragm means for transmitting the actuation force from said switch actuator means to said diaphragm means.

6. A keyboard comprising:

switch card means, having a plurality of arrays of three or more switching element means and conductive land pattern and throughhole means connecting said switching elements to a plurality of groups of output connector means, with each switching element means of each array connected to an output connector means of one of said groups, for producing an output code,

elastic diaphragm means comprising a thin continuous sheet of conductive spring material for providing a voltage source,

separator means disposed between said diaphragm means and said switch card and having an opening at each array of switching elements for electrically insulating said switching element means and land pattern means from said diaphragm means, and

a plurality of switch actuator means, one for each of said arrays of switching elements, for selectively deflecting said diaphragm means through one of said openings in said separator means into electrical contact with each said element of its associated array,

whereby actuation of one of said switch actuator means will produce an output signal at said output locations.

7. The keyboard of claim 6 wherein said output locations comprise a plurality of groups of output connectors, one of said groups being uniquely associated with a corresponding switching element from each said array, each said switching element being connected by double sided wiring to one and only one output connector of its associated group.

8. The keyboard of claim 7 further comprising rollover logic means for detecting the presence of positive logic levels at more than one output connector of any of said groups of output connectors.

9. The keyboard of claim 7, further comprising strobe logic means responsive to the output code at said output connector means for detecting that each group of output connectors has a positive logic signal on one of its output connectors.

10. An electronic keyboard apparatus having a plurality of key locations for generating a unique output code for each key, comprising:

elastic diaphragm means comprising a thin sheet of conductive spring material for providing a voltage source,

switch card means for generating an output code signal comprising

a substrate,

a plurality of arrays of switch element means on the surface of said substrate, one said array for each said key location, for defining the code for said each key,

a plurality of groups of output connector means for providing the output signal from said switch card means,

wiring means for electrically connecting said switch element means and said output connector means with one switch element means from each said array connected to at least one output connector means of each of said groups,

separator means for separating said diaphragm means and said switch card means,

a plurality of switch actuator means, one for each said key location, for deflecting said diaphragm means through an opening in said separator means into electrical contact with the switch element means of its corresponding array,

rollover protection logic means for detecting simultaneous output signals from a plurality of output connector means within a given group, and

strobe logic means for detecting that an output signal is present at at least one output connector means within each said group,

whereby a valid multibit output character is generated at said groups of output connector means when one and only one switch actuator means is actuated to move said diaphragm means into electrical contact with all of the switch element means of its associated array.

11. The keyboard of claim 2 further comprising strobe logic means responsive to the output code at said pins for detecting electrical contact between said diaphragm and all of the switching elements of an array.

12. The keyboard of claim 8, further comprising strobe logic means responsive to the output code at said output connector means for detecting that each group of output connectors has a positive logic signal on one of its output connectors.

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