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Hoffman

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[45] **July 3, 1973**

[54] **STROKE CODED KEYBOARD SWITCH ASSEMBLY**

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[73] Assignee: **Bell Telephone Laboratories, Incorporated,** Murray Hill, N.J.

[22] Filed: **Aug. 30, 1971**

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

[51] **Int. Cl.** **H01h 41/00**

[58] **Field of Search** ..... 200/5, 159 B; 179/90 K

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Primary Examiner—J. R. Scott

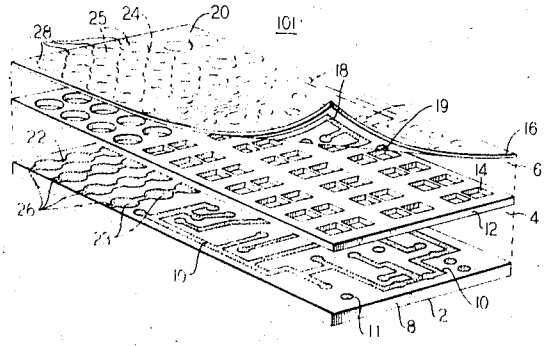
Attorney—W. L. Keefauver et al.

[57] **ABSTRACT**

A stroke coded keyboard utilizes a switch matrix having crosspoints comprising deformable membrane contacts or switches. Each keyboard character or element is defined by the signals generated by the closure of contacts which produce a specified sequence of connections of i pairs of first (n) and second (m) conductors so that $(nm)^i$ distinct characters can be defined on the keyboard by $n+m$ unique conductors, where n and m are any positive integers greater than one and i is any positive integer greater than one and less than or equal to nm. An element can be keyed very rapidly by the stroke of a stylus on the top surface of the keyboard which sequentially closes the contacts defining the element. The keyboard can be utilized in many configurations such as a data entry keyboard, repertory dialer, or in parallel with or as a replacement for telephone keyboards.

The character element is defined by the signals generated by a specified sequence of connections of i pairs of first (n) and second (m) conductors so that (nm) distinct characters can be defined on the keyboard by N + M conductors, where n and m are any positive integers greater than one and i is any positive integer greater than one or less than or equal to nm.

16 Claims, 5 Drawing Figures



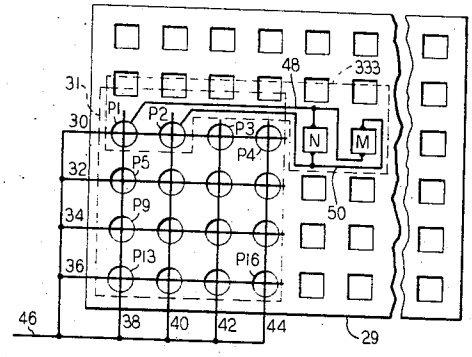


FIG. 1

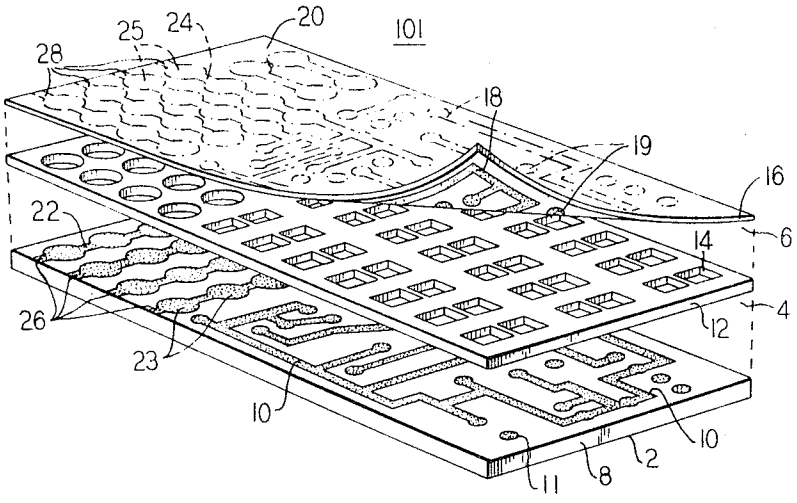

101
20
25
24
28
18
19
16
6
22
14
4
12
26
23
10
10
2
11
8

FIG. 2

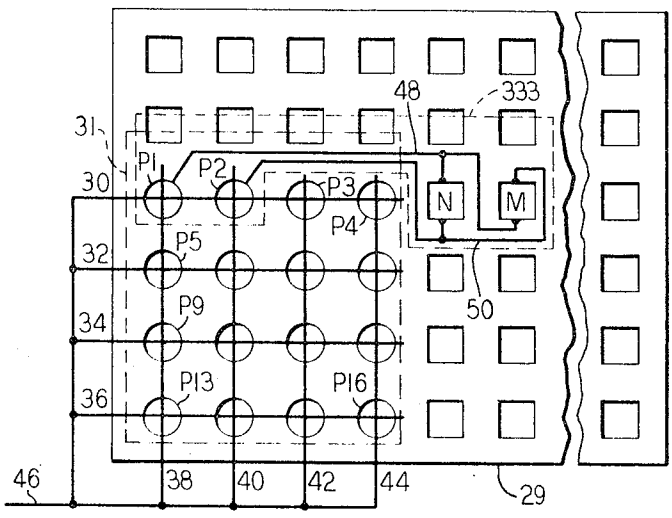

48
333
31
P1
P2
P3
30
N
M
P4
P5
32
50
P9
34
P13
P16
36
46
38
40
42
44
29

FIG. 3

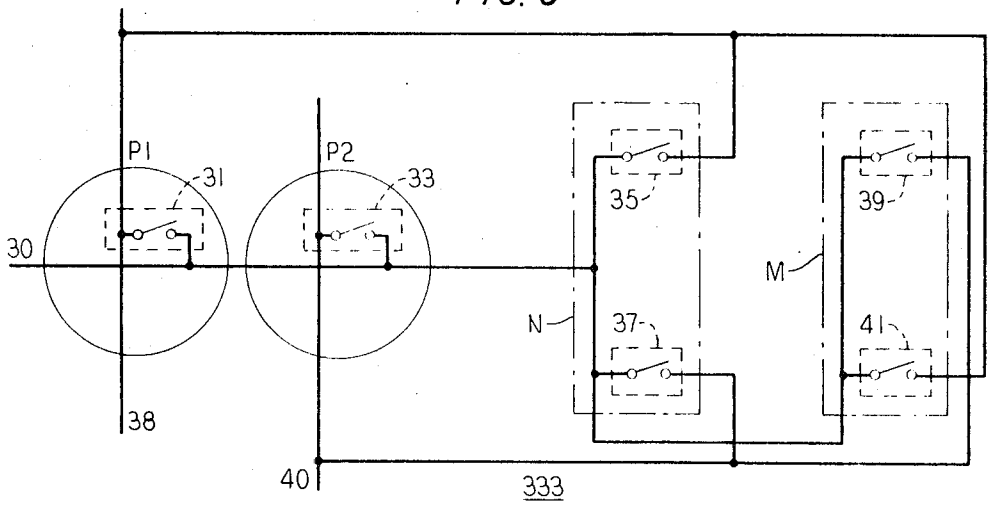

P1
31
P2
33
30
35
39
M
N
37
41
38
40
333

FIG. 4

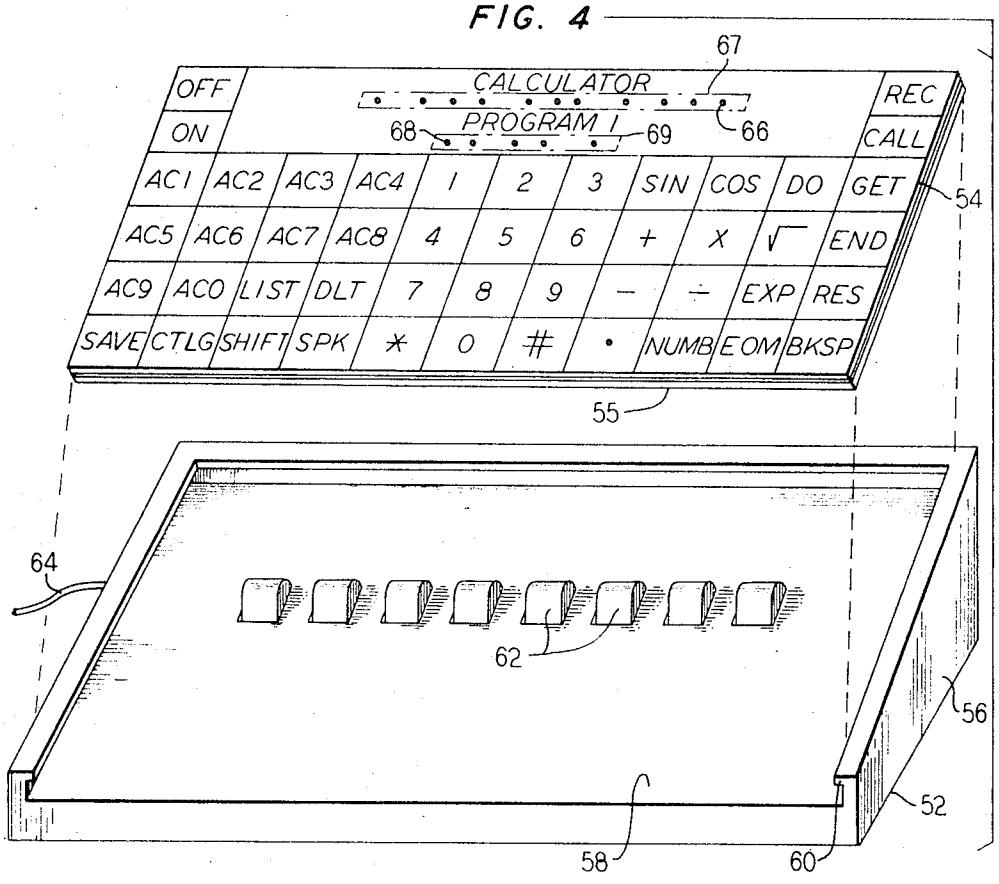

67
OFF
CALCULATOR
REC
ON
68
PROGRAM I
69
66
CALL
AC1 AC2 AC3 AC4 1 2 3 SIN COS DO GET
54
AC5 AC6 AC7 AC8 4 5 6 + X √ END
AC9 AC0 LIST DLT 7 8 9 − ÷ EXP RES
SAVE CTLG SHIFT SPK * 0 # • NUMB EOM BKSP
55
64
62
56
52
58
60

FIG. 5

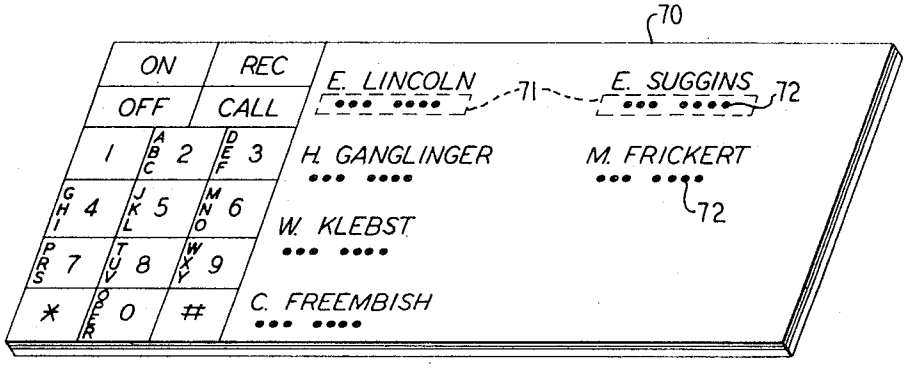

70
ON
REC
OFF
CALL
1
2
3
4
5
6
7
8
9
*
0
#
E. LINCOLN
71
E. SUGGINS
72
H. GANGLINGER
M. FRICKERT
72
W. KLEBST
C. FREEMBISH

FIG. 6

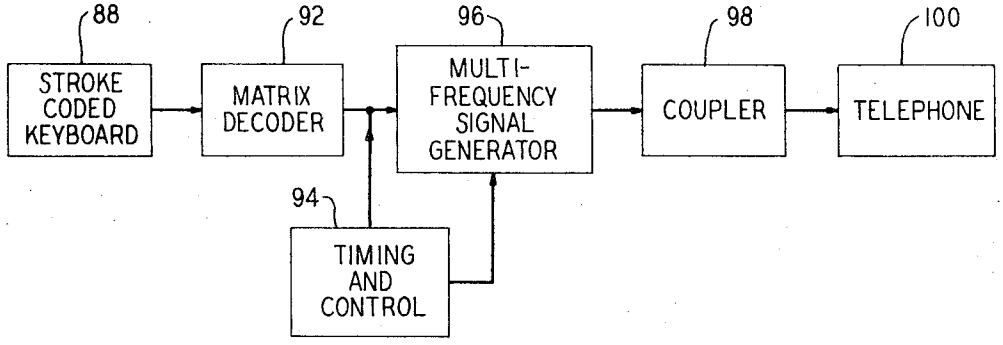

88
STROKE CODED KEYBOARD
92
MATRIX DECODER
96
MULTI-FREQUENCY SIGNAL GENERATOR
98
COUPLER
100
TELEPHONE
94
TIMING AND CONTROL

FIG. 7

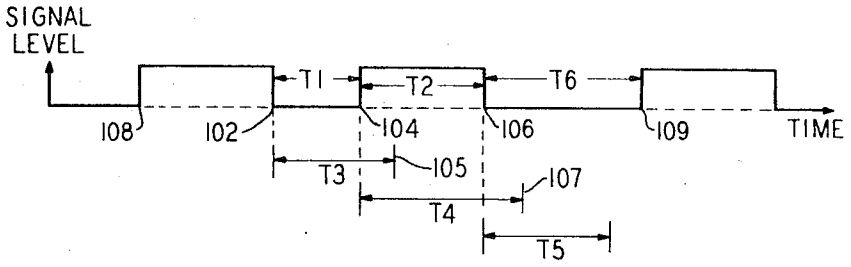

SIGNAL LEVEL
T1
T2
T6
108
102
104
106
109
TIME
T3
105
107
T4
T5

FIG. 8

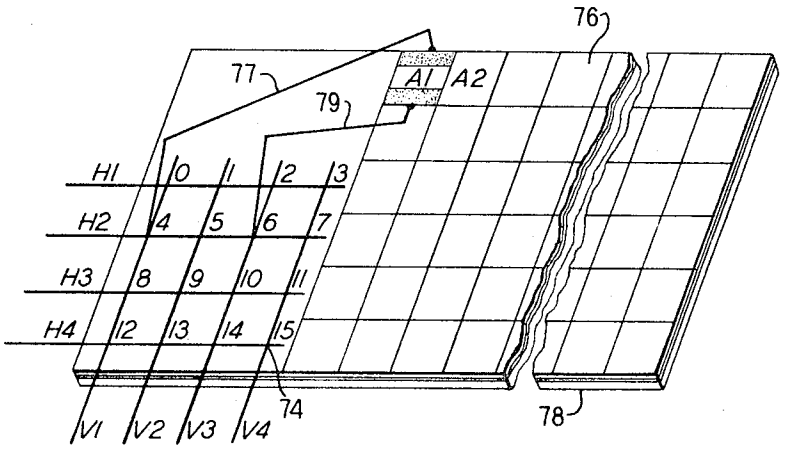
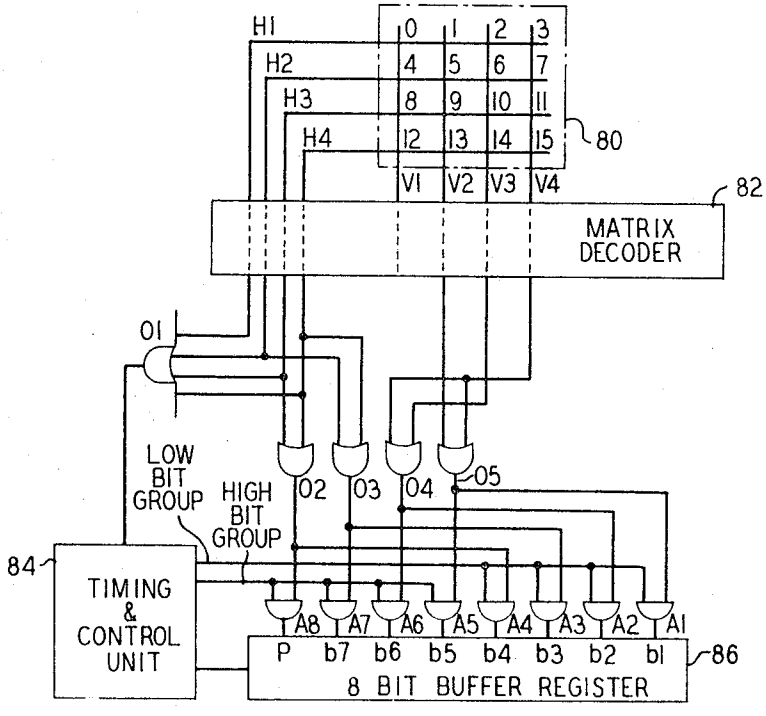

76
77
A1
A2
79
H1
H2
H3
H4
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
74
78
V1
V2
V3
V4

FIG. 9

DECIMAL DESIGNATION OF CROSSPOINTS	V1	V2	V3	V4	H1	H2	H3	H4	BINARY EQUIVALENT OF DECIMAL DESIGNATION B_4	B_3	B_2	B_1
0	1				1				0	0	0	0
1		1			1				0	0	0	1
2			1		1				0	0	1	0
3				1	1				0	0	1	1
4	1					1			0	1	0	0
5		1				1			0	1	0	1
6			1			1			0	1	1	0
7				1		1			0	1	1	1
8	1						1		1	0	0	0
9		1					1		1	0	0	1
10			1				1		1	0	1	0
11				1			1		1	0	1	1
12	1							1	1	1	0	0
13		1						1	1	1	0	1
14			1					1	1	1	1	0
15				1				1	1	1	1	1

FIG. 10



STROKE CODED KEYBOARD SWITCH ASSEMBLY

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to keyboards and more particularly to miniature stroke coded keyboards for use in a telephone system in such applications as telephone keyboards, data entry keyboards and repertory dialers.

2. Description of the Prior Art

The telephone network is finding increasing usage for the transmission of data such as computer input and output data, inventory control data, sales or order data, etc. Presently, most data of the previously mentioned types is transmitted through the use of teletypewriter sets or through multi-frequency signaling means of a multi-frequency signaling push-button telephone. Teletypewriter sets are not always readily available where needed and, additionally, are too expensive to be economically feasible for the part-time user. Multiple-key encoding of information by means of a push-button telephone set is relatively slow and may be inconvenient in a desk-top environment where encoding concurrently with pencil calculations or writings is desirable. Thus a need remains for a keyboard or interface which has greater efficiency than multiple-key encoding and is sufficiently flexible to permit efficient usage in different environments while simultaneously being economically feasible.

Accordingly, it is an object of this invention to enhance the efficiency of keyboards for accessing the telephone network.

Another object is to improve the flexibility of keyboards to make their use more convenient in various environments.

Another object is to improve keyboards to provide more rapid encoding of information than is possible with multiple-key encoding.

SUMMARY OF THE INVENTION

The foregoing objects and others are achieved in accordance with the principles of this invention through the use of a miniature stroke coded keyboard which can be used as a replacement for, or in parallel with, a multifrequency signaling push-button telephone keyboard. The keyboard has an $(n \times m)$ crosspoint matrix of pressure sensitive diaphram switches which define $(n \times m)$ unique crosspoints but which require only $(n + m)$ output leads. The unique crosspoints are elecrically connected in prescribed combinations to contacts which define specific keyboard characters or elements such as letters, numbers, computer instructions and the like which are indicated by the keyboard keys. Different orders of coding can be provided by defining the keyboard elements by different numbers of crosspoints. The keyboard elements or characters are keyed by stroking the pressure sensitive diaphram with a stylus thereby sequentially closing the normally open contacts. The keying of information can be accomplished much more quickly than by multiple-key encoding because of the stroking action. A single keyboard can be used for all encoding or, alternatively, special purpose keyboards can be designed for specific applications thereby giving an optimum layout of keyboard elements.

BRIEF DESCRIPTION OF THE DRAWING

The invention will be more fully comprehended from the following detailed description and accompanying drawing in which:

FIG. 1 is an exploded perspective view of a stroke coded keyboard in accordance with the invention;

FIG. 2 is a schematic representation of the keyboard of FIG. 1;

FIG. 3 is an enlarged schematic representation of portion 333 of FIG. 2;

FIG. 4 is an exploded perspective view of a special purpose keyboard and a holder for mounting the keyboard;

FIG. 5 is a perspective view of another special purpose keyboard which can be used with the holder of FIG. 4;

FIG. 6 is a block diagram representation of a stroke coded keyboard system including auxiliary apparatus for improving keyboard operation;

FIG. 7 is a timing diagram for the system of FIG. 6;

FIG. 8 is a schematic representation of a keyboard for generating the USASCII code;

FIG. 9 is a truth table for the keyboard of FIG. 8; and

FIG. 10 is a schematic representation of a system for implementing equations derived from the truth table in FIG. 9.

DETAILED DESCRIPTION

FIG. 1 is an exploded perspective view of a stroke coded keyboard **101** in accordance with the principles of the invention. Keyboard **101** comprises a sandwich construction including a base assembly **2**, an overlaying insulating spacer **4**, and a deformable or flexible membrane **6** overlaying spacer **4**. Assembly **2**, spacer **4** and membrane **6** can be adhered or joined together by an appropriate adhesive such as commercially available pressure sensitive adhesive. Base assembly **2** can comprise a substrate **8** of glass, ceramic, or other suitable material having a pattern of conductors **10** and lands **11** on the top surface thereof. Conductors **10** and lands **11** can be formed by well known techniques such as vacuum deposition of gold and photo-etching.

Spacer **4** comprises a thin sheet **12** of insulating material having a number of openings **14** therein for reasons to be subsequently explained. A suitable spacer **4** can be formed by mechanically making openings in a thin sheet of material such as a polyester film which is commercially available. Spacer **4** can also be formed from a photosensitive material by known masking and etching techniques.

Deformable membrane **6** comprises a thin sheet **16** of flexible insulating material, such as the previously mentioned polyester film or acetate, having a pattern of conductors **18** and lands **19** on the bottom surface thereof. Conductors **18** and lands **19** can be formed by the previously mentioned vacuum deposition of gold or by other techniques known in the art. The keyboard keys indicating the characters or elements of the keyboard are designated on sheet **16**. Sheet **16** has a smooth top surface **20** which is wear resistant to strokes of a stylus for reasons to become apparent subsequently. When pressure is applied to top surface **20** by means of a stylus or pencil, sheet **16** deforms through any opening **14** under the stylus so that any land **19** aligned with opening **14** will contact any land **11** on substrate **8** which is also aligned with the opening **14**.

Thus lands **11** and **19** can be utilized as respective terminals of a contact or switch as will be subsequently shown. The pressure required for deforming sheet **16** to cause contact between lands **11** and **19** depends upon such factors as the thickness and resulting flexibility of sheet **16**, the thickness of spacer sheet **12** and the size of openings **14**. A pressure range from a few grams to several ounces is easily obtainable. Openings **14** are usually large with respect to the thickness of sheet **12** and thus the relative dimensions shown are for illustration only.

The intersection of conductors **22** and **24** on substrate **8** and sheet **16**, respectively, at which points lands **23** and **25** are located, define the crosspoints of a switch matrix which is the foundation for the keyboard of this invention. The crosspoints can be closed and thereby a connection completed by deforming membrane **6** as previously discussed. A (4 × 4) matrix having 16 crosspoints is shown and described in detail below. However, it will be readily apparent that the following discussion would apply equally as well to a ($n \times m$) matrix where n and m may be any desired positive integers.

Referring now to FIG. **2** and **3**, the construction of the keyboard of FIG. **1** is schematically illustrated. Four horizontal conductors **30, 32, 34** and **36** and four vertical conductors **38, 40, 42** and **44** of a matrix **31** define 16 unique crosspoints or contact points **P1, P2, . . . P16** while requiring only 8 output leads which may be readily combined into a single multiconductor cable **46**. Matrix **31** could itself be used as a simple keyboard having 16 elements or characters each of which is defined by one of the crosspoints **P1 . . . P16** comprising diaphragm or membrane switches. The term element or character is used herein generically to include numbers, letters, mathematical functions such as plus and minus and computer instructions, etc., which comprise the keys of various types of keyboards. These switches could be activated and thereby the keyboard elements keyed by deforming the flexible diaphragm as previously discussed. However, in most applications a keyboard having only sixteen distinct elements would not be adequate. According to applicant's invention, the keyboard elements are defined by sequential combinations of more than one crosspoint so that a large number of distinct keyboard elements can be obtained without losing the advantages of using a small matrix, i.e., limited number of output leads, extremely small keyboard size, etc. In essence, defining each keyboard element by a single crosspoint can be considered as first-order coding. Defining an element by two crosspoints constitutes second-order coding, etc. The number of unique keyboard elements which can be defined by a matrix is x^i where x is the number of matrix crosspoints and i is the order of the coding.

In applicant's illustrative embodiment, second-order coding is utilized, i.e., each keyboard element is defined by a sequential pair of crosspoints. Hence the 16 crosspoints of the (4 × 4) matrix can define 256 distinct keyboard elements, i.e., 16^2. The specification of a sequential pair of crosspoints determines both the crosspoints to be utilized in defining the element and the manner in which the crosspoints are connected to the element as will be shown subsequently.

The term "defining a keyboard element" means that the matrix crosspoints chosen to define the element are electrically connected to respective contact terminals under the face of the element which can then be operated by keying the element, i.e., applying pressure to the keyboard key indicating the element as previously discussed. For example, the sequential pair of crosspoints **P1** and **P2** can be specified as defining keyboard element "N" which may be a number, letter, computer instruction, etc. Crosspoints **P1** and **P2** are connected to element "N" in a manner such that when element "N" is keyed in the proper way, the output from keyboard **29** on cable **46** will appear as a sequential closure or operation of crosspoints **P1** and **P2.**

In the illustrative embodiment shown in greater detail in FIG. **3**, crosspoint **P1** is defined by the intersection of vertical conductor **38** and horizontal conductor **30.** **P1** is operated, thereby connecting conductors **30** and **38**, by applying pressure to the keyboard where crosspoint **P1** is located. This can be represented by the closure of a switch **31.** Crosspoint **P2** is defined by the intersection of vertical conductor **40** and horizontal conductor **30** and the operation thereof can be represented by the closure of switch **33.** In defining element "N" by the sequential pair of crosspoints **P1** and **P2**, the conductors defining **P1** and **P2** are connected to terminals of respective contacts or switches located under the face of element "N." That is, conductors **38** and **30**, defining crosspoint **P1**, are connected to respective terminals of contact or switch **35.** Conductors **40** and **30**, defining crosspoint **P2**, are connected to respective terminals of contact **37.** In essence, contacts **35** and **37** are in parallel with crosspoints **P1** and **P2**, respectively, and the closure of contact **35** or **37** appears the same as the closure or operation of **P1** or **P2**, respectively, with respect to the signal on cable **46.** Because element N is defined by the sequential pair of crosspoints **P1** and **P2**, the output on cable **46** is interpreted as element N whenever crosspoints **P1** and **P2** are operated in the indicated sequence, or alternatively whenever contacts **35** and **37** are closed in that order.

In the illustrative embodiment, the horizontal conductor **30** is connected to contact terminals which comprise lands **19** on membrane sheet **16.** Vertical conductors **38** and **40** are connected to respective contact terminals which comprise lands **11** on substrate **8.** Thus contacts **35** and **37** are sequentially closed by sequentially applying pressure to the surface of membrane **6** where the appropriate lands are located, i.e., applying pressure to the keyboard key indicating element N. Because contacts **35** and **37** are in parallel with crosspoints **P1** and **P2**, respectively, and the operation of the contacts produces the same output as the operation of the respective parallel crosspoint, it is not necessary that matrix **31** itself physically appear on the keyboard. That is, the contacts themselves act essentially as matrix crosspoints which are located in a pattern other than a standard matrix pattern.

Pairs of mating lands **11** and **19** representing the terminals of respective contacts **35** and **37** are aligned with closely adjacent openings **14** in spacer **12** and the pair of contacts is labeled as the single key N representing element N on the surface of membrane sheet **16.** Element N can then be keyed by applying pressure to sequentially deform membrane **6** through the respective openings **14** thereby sequentially closing contacts **35** and **37.** The keying advantageously can be done very rapidly by stroking a stylus, pencil or the like across the face of key N, i.e., from top to bottom in the illustrative embodiment. The stroke keying or coding

technique offers significant advantages, especially in speed and ease of keying, over techniques such as multiple depressions of buttons or keys required by other keyboards. The stroke keying or coding is permitted by the smooth upper surface **20** of membrane sheet **16.**

The crosspoints P1 and P2 can be used to define a second keyboard element M when designated as the sequential pair P2 and P1. This is possible because the sequence of closures for the pair P2 and P1 is different from the sequence of closures for the pair P1 and P2 used to define element N. If element M is defined by the sequential contact pair P2 and P1 then the connections **48** and **50** are connected to the bottom and top portions, respectively, of keyboard element M. Thus element M is keyed or coded by a stylus stroke from top to bottom on the face of the key representing element or character M. All other elements on the keyboard are defined similarly by connection from specified combinations of the matrix crosspoints to respective top and bottom portions of the elements.

Ordinarily it is desirable for all keyboard elements to be coded by stylus strokes in the same direction, i.e., from top to bottom on the element face in the illustrative embodiment. However, if strokes in other directions are permitted, various keyboard elements can be combined into a single composite key, the output from which will be dependent upon the stroking direction. For example, illustrative elements N and M could be combined into a single keyboard key, the output from which represents element N when the composite key is stroked from top to bottom and which represents element M when the composite key is stroked from bottom to top. Such composite keyboard keys might be desirable on an alphanumeric keyboard where both upper and lower case characters are needed but where keyboard space is limited. In such case for example, a top to bottom stroke could key a capital letter while a bottom to top stroke on the same keyboard key could key the corresponding lower case letter.

As previously mentioned, the keyboard of this invention can be used as a substitute for, or in parallel with, a regular multi-frequency signaling push-button telephone keyboard. Different versions of the keyboard can be designed as alphanumeric terminals, calculator terminals, repertory dialers, special business terminals such as for placing merchandise orders, and numerous other special applications. Because all coding is done on the keyboard itself through the specification of the specific pairs of crosspoints which define the keyboard elements, the output leads from the keyboard, i.e., the leads from the crosspoint matrix, remain fixed regardless of the specific type keyboard being used. Thus a basic keyboard structure with interchangeable keyboards can be utilized.

FIG. **4** shows a basic keyboard holder **52** and one version of a keyboard **54** which can be used therewith. Holder **52** includes a frame **56** which defines a compartment **58** into which keyboard **54** can be slid. A lip or flange **60** around the periphery of frame **56** holds keyboard **54** in position. Holder **52** also includes eight contacts **62** which connect with the eight output leads from the 4 × 4 crosspoint matrix which is utilized. These output leads normally terminate in printed circuit lands on the bottom surface **55** of keyboard **54.** The contacts **62** terminate multiconductor cable **64** which connects the keyboard assembly into the telephone system.

Keyboard **54** is constructed as previously described with reference to FIG. **1** through FIG. **3.** The eight output leads from the matrix can be in the form of printed circuit conductors and contact terminals on the bottom side **55** of the keyboard. Because all conductors and contacts are formed by printed circuit techniques and a stylus is used for keying, the keyboard can be made quite small in size. Keyboard **54** advantageously can be the approximate size of a standard credit card so that it can be conveniently carried for use wherever needed. In the illustrative embodiment keyboard **54** is designed for use as a calculator terminal in conjunction with a computer such as a time-shared computer or the like. A total of **48** keyboard elements is illustrated including numbers, computer instructions and local controls such as ON and OFF for controlling the keyboard operation. The numbers and types of keyboard elements indicated is purely illustrative. Any number of elements up to 256 could be utilized. The elements of keyboard **54** are defined as previously discussed with respect to FIG. **1** through **3.**

Normally it is necessary to dial or key a telephone number to access a computer from a remote terminal. This is especially true in commercial time-shared computer systems. Keyboard **54** is designed to permit this dialing by underlining the keyboard title, i.e., drawing a line through the series of contacts represented by dots **66** under the title CALCULATOR. Each dot **66** is a contact connected to a matrix crosspoint representing a digit of the desired telephone number. Thus dots **66** define element **67** in the same manner as other keyboard elements except that more crosspoints are utilized in the definition. For example, the contacts represented by dots **66** define keyboard key or element **67** in the same manner as contacts **35** and **37** define keyboard element N in FIGS. **2** and **3.** The designation of the particular terminal or user also can be keyed by underlining such designation on the keyboard, i.e., keying element **69** by stroking through dots **68** which comprise digits or numbers in the designation. Each of the other keyboard elements or keys such as ACl, AC4, COS, CALL, etc., are defined by a unique combination of crosspoints in the same manner as previously discussed with reference to FIGS. **2** and **3.**

A second type of keyboard **70** for use in frame **56** is shown in FIG. **5.** Keyboard **70** essentially serves as an inexpensive telephone repertory dialer. The keyboard elements **71** representing the telephone numbers comprise contacts represented by the dots **72** under the names listed. Each contact or dot is connected to a crosspoint representing a digit. The telephone numbers are keyed or dialed by a simple stroke of the stylus through the dots **72** underlying the desired name. Different keyboards **70** representing different repertory dialers can for example be made for business numbers, personal numbers, etc., and used interchangeably in holder **56.**

It should be apparent from the foregoing examples and discussion that numerous types of keyboards for special applications can readily be designed. The basic apparatus, i.e., the number of output leads, the keyboard holder, etc., can remain fixed in all such keyboards. The coding for special applications is designed into the keyboard elements and thus the layout, appearance, etc., of any keyboard can be optimized for its specific application. The keying by stylus strokes can

be utilized on all such keyboards for efficient keying operation.

The keyboards of this invention can be utilized as replacements for, or in parallel with, a standard multi-frequency signaling push-button telephone keyboard. When used in the former application the keyboard can utilize the basic circuitry of the telephone set including the multi-frequency signal generator therein to produce its output signals. In the latter application the keyboard can also utilize the basic telephone set circuitry. In such case an appropriate connection such as a pin and socket connector can be provided on the telephone set for connecting the keyboard into the telephone set circuitry at the appropriate points. Alternatively, the keyboard can have its own self-contained auxiliary circuitry such as a multi-frequency signal generator.

FIG. 6 is a block diagram of a keyboard system in which a stroke coded keyboard **88** is utilized in conjunction with additional apparatus for enhancing the operation of the stroke coded keyboard. When the elements of keyboard **88** are stroked very rapidly, the pulse duration upon contact closure may not be sufficient for compatability with the telephone switching network. Further, the spacing required between pulses by the switching network may be greater than that obtained during rapid keying strokes. Accordingly, timing and control unit **94** can contain well known circuitry such as monostable multivibrators for insuring proper pulse duration and separation.

Another problem which may be encounted in using stroke coded keyboard **88** is contact bounce which causes uncertainty whether or not an element has actually been keyed. A simple resistive-capacitive integration circuit in timing and control unit **94** can minimize this problem by integrating the contact closure signals for a short period. The multivibrators previously mentioned also help eliminate the problem of contact bounce.

Circuitry advantageously can be provided in timing and control unit **94** for grouping the contact closure signals from keyboard **88** into the correct pairs representing a specific keyboard element. For example, if the keyboard elements are defined by pairs of contacts the grouping circuitry can provide for the cancellation of a contact closure signal after a specified interval if the second contact closure signal of the pair has not been received. This grouping feature can be of significant value in reducing errors in coding. The grouping circuitry will require a small memory in timing and control unit **94** for efficient operation. The functioning of grouping circuitry will be explained with reference to FIG. 7 showing a timing diagram therefor.

The timing periods for the grouping circuit can be established by well known techniques such as by monostable multivibrators. At point **108** in the timing diagram the first contact used in defining a keyboard element is closed by pressure from a stylus. The signal representing this closure is stored in the previously mentioned memory and a feedback such as an audible click or blinking light can readily be provided to indicate keying of this first contact. At point **102** the contact is released when the operating pressure is removed and also a multivibrator fires to initiate timing period **T3.** At point **104** the second contact used in defining the keyboard element is closed by stylus pressure. If the time period **T1** between the release of the first contact at point **102** and the closure of the second contact at point **104** is less than the timing period **T3,** the second contact closure is grouped with the first closure to register the completion of the keying of the indicated keyboard element and the appropriate signal is then transmitted to the telephone network. If period **T1** exceeds time period **T3,** i.e., a second contact closure has not been made in the time period **T3,** the first contact closure is erased from the memory at point **105** at the end of period **T3** and the next contact closure is treated as the first contact closure in the keying of another keyboard element.

When the second contact closure is made at point **104,** a second multivibrator is also fired initiating timing period **T4** which ends at point **107.** Period **T2** indicates the length of time that the second contact remains closed. If period **T2** exceeds timing period **T4,** the grouping circuitry will continue repeating the keyboard element which has just been keyed with the proper signal duration, etc., until the pressure is removed and the contact is opened. A multivibrator is fired at the termination of period **T2** at point **106** to initiate timing period **T5.** Timing period **T5** is the period of time required to elapse after the completion of keying one keyboard element at point **106** until the keying of a subsequent keyboard element can be initiated at point **109.** If the actual period **T6** between points **106** and **109** is less than timing period **T5** the contact closure at point **109** is not recognized and the multivibrator is refired to reinitiate timing period **T5.**

Timing periods **T3** and **T5** are specified to give minimal error rates from such factors as overstroking an element or inadvertent stroking or poking an element. The optimum timing periods may vary depending on the type of keyboard being utilized, the training of the operator, etc. Timing period **T4** is selected to give acceptable repeat operation of keyboard elements.

The output from the stroke coded keyboard **88** on the eight output leads previously mentioned is fed to matrix decoder **92** which decodes this output to determine the crosspoints which define the keyboard element which has been keyed. Decoder **92** comprises well known logic circuitry for producing an output signal responsive to the particular input terminals on which an input signal appears. Decoder **92** can also include buffer amplifiers for providing the proper levels to the output of decoder **92.** The output from decoder **92** controls multi-frequency signal generator **96** which produces the actual tones by which information is transmitted from keyboard **88** to the telephone network. Generator **96** can be the same unit as that used to generate the signaling tones in a standard multi-frequency signaling telephone. Alternatively, generator **96** can be an integrated circuit tone generator in order to have a size more compatible with the minature size of keyboard **88.**

When used in parallel with a telephone keyboard, keyboard **88** must be coupled to the telephone **100** by an appropriate coupler **98.** Coupler **98** can comprise an acoustic coupler known in the art which fits over the telephone set mouthpiece and acoustically couples signals from generator **96** into telephone set **100.** Coupler **98** can also comprise circuitry as previously mentioned which electrically couples the signals from generator **96** into telephone set **100** at the appropriate points.

The principles of this invention can be used in a keyboard which, along with some simple logic circuitry, can be utilized to generate special codes such as the

United States American Society for Communication and Information Interchange Code (USASCII Code). Because the USASCII Code contains 128 elements, a (4 × 4) matrix using second-order stroke coding is sufficent to generate the complete code because as previously mentioned such a matrix can define up to 256 unique characters.

The USASCII Code is an eight bit code comprising seven information bits and a parity bit for each character. The parity bit can be grouped with the information bits and these eight bits then can be broken into two bit groups, designated the high bit group and low bit group, each having four bits. Each bit group can be represented by an equivalent decimal number between zero and 15. As schematically illustrated in FIG. **8**, the crosspoints **74** of the (4 × 4) switch matrix can also be designated between zero and 15 and the appropriate combination of crosspoints can be connected to the designated character defined thereby on keyboard **78**.

From the truth table shown in FIG. **9**, logical equations sufficient to define each bit position "B" for each bit group can be derived as follows:

$B_{1i} = V_2 + V_4$
$B_{2i} = V_3 + V_4$
$B_{3i} = H_2 + H_4$
$B_{4i} = H_3 + H_4$

where:

i = L for the low bit group;
i = H for the high bit group;
B_{1i} = the least significant digit in the bit group, etc.;
V_2, V_3, V_4 = the second, third and fourth columns or vertical conductors in the matrix, respectively; and
H_2, H_3, H_4 = the second, third and fourth rows or horizontal conductors in the matrix, respectively.

Thus, for example, USASCII element A1 on keyboard **78** might be defined by the decimal designation 04,06 which is represented by the connections **77** and **79** from crosspoints **4** and **6**, respectively, to the top and bottom contacts respectively, defining element A1. The sequential closure of the top and bottom contacts under element A1 will produce the USASCII character 01000110 which is the binary representation of 04,06. This designation or definition of element A1 represents the character "F" with odd parity in the actual USASCII Code. A USASCII binary character can in general be represented by P b_7 b_6 b_5 b_4 b_3 b_2 b_1 where:

$b_1 = B_{1L}$
$b_2 = B_{2L}$
$b_3 = B_{3L}$
$b_4 = B_{4L}$
$b_5 = B_{1H}$
$b_6 = B_{2H}$
$b_7 = B_{3H}$
$P = B_{4H}$

where:

b_1 = the least significant bit in the character, etc.; and
P = the parity bit.

The logical equations representing the bits can be implemented and thereby the USASCII characters generated by the simple two-level logic illustrated in FIG. **10**. The outputs of the USASCII stroke coded keyboard **80** are fed to a matrix decoder **82** such as that previously discussed. The outputs from matrix decoder **82** are combined by OR gates **02, 03, 04,** and **05**. The outputs are also connected to OR gate **01** which triggers timing and control unit **84**. Timing and control unit **84** includes substantially the same apparatus as that previously discussed with respect to timing and control unit **94** in FIG. **6**. Unit **84** also gates the outputs from OR gates **02** through **05** into appropriate bit positions in buffer register **86** by triggering AND gates A1 through A8. The data stored in register **86** is in the USASCII format comprising seven information bits b_1 through b_7 and one parity bit P and can be outputed either serially or in parallel. Timing and control unit **84** resets buffer **86** as needed after inputs are taken therefrom. Register **86**, OR gates **01** through **05** and AND gates A1 through A8 comprise circuits well known in the art.

While the invention has been described with reference to specific embodiments thereof, it is to be understood that various modifications thereto might be made by those skilled in the art without departing from the spirit and scope of the following claims.

What is claimed is:

1. A keyboard having a plurality of keys indicative of a plurality of characters comprising a substrate having first conductors thereon, an insulating spacer positioned on said substrate and having openings therethrough, and a deformable membrane positioned on said spacer and adapted for movement through said openings, said membrane having second conductors thereon, characterized in that:

each of said characters is defined by signals generated by connections of a plurality of said first conductors with a plurality of said second conductors in a specified sequence; and

said keyboard includes means responsive to a pressure stroke in a first direction applied across one of said keys for establishing said connections in a first one of said specified sequences and for generating said signals indicative of a first one of said characters.

2. Apparatus in accordance with claim **1** wherein said first conductors comprise n unique conductors, said second conductors comprise m unique conductors, and said character is defined by said signals generated by said specified sequence of connections of i pairs of said first and second conductors so that $(nm)^i$ distinct characters can be defined on said keyboard by $n+m$ unique conductors, where n and m are any positive integers greater than one and i is any positive integer greater than one and less than or equal to nm:

3. Apparatus in accordance with claim **2** where n and m each equal four and i equals two whereby 256 distinct characters can be defined on said keyboard by eight unique conductors.

4. Apparatus in accordance with claim **1** wherein said responsive means comprises:

a plurality of first contact members within designated switching areas on said substrate, said first contact members within each of said switching areas being connected to a respective one of said plurality of first conductors; and

a plurality of second contact members within areas defined by said keys on said membrane corresponding to said switching areas, said second contact members within each of said defined areas being connected to a respective one of said plurality of second conductors, said first and second contact members being arranged for sequential connection of respective ones thereof in response to said pressure stroke.

5. Apparatus in accordance with claim **1** wherein said one of said keys is indicative of a plurality of said char-

acters and said responsive means is responsive to a pressure stroke applied across said one of said keys in a second direction for establishing said connections in a second one of said specified sequences and for generating said signals indicative of a second one of said characters.

6. Appparatus for generating encoded electrical signals comprising, in combination:

a keyboard structure having a plurality of keys indicative of a plurality of characters;

first and second groups of conductors, a plurality of said first and second groups of conductors being associated with one of said keys; and

means responsive to a pressure stroke applied across said one of said keys in a first direction for connecting said plurality of said first group of conductors to said plurality of said second group of conductors in a first sequential order and for generating signals indicative of a first one of said characters.

7. Apparatus in accordance with claim 6 including means for grouping said signals into said first sequential order representing the keying of said first one of said characters so that errors in said keying can be reduced, comprising:

first means for designating the first of said signals asthe first signal in said first sequential order;

first timing means for initiating a first timing period upon the completion of said first signal;

second means for designating the second of said signals as the second signal in said first sequential order when said second of said signals is received before the expiration of said first timing period, said second designating means being responsive to said first timing means to reject said second of said signals and to initialize said first designating means by removing said first signal therefrom when said first timing period expires before said second of said signals is received so that signals caused by inadvertent touching of said keys can be eliminated.

8. Apparatus in accordance with claim 7 wherein said first timing period has a duration adapted to cause rejection of signals produced by discrete pokes on said keys and to cause signals produced by strokes on said keys to be designated as signals in said first sequential order.

9. Apparatus in accordance with claim 7 including a second timing means for initiating a second timing period when said second of said signals is received before the expiration of said first timing period; and

third means for repeatedly designating said first and second of said signals as said first and second signals, respectively, in respective ones of said first sequential orders when said second of said signals has a duration greater than said second timing period, said third designating means being responsive to the termination of said second of said signals to cease operation whereby automatic repeat keying of said first one of said characters can be obtained.

10. Apparatus in accordance with claim 7 including a third timing means responsive to the termination of said second of said signals for initiating a third timing period; and

means for rejecting subsequent ones of said signals until the expiration of said third timing period thereby to eliminate signals caused by keying strokes extending beyond said one of said keys.

11. Apparatus in accordance with claim 10 including means for reinitiating said third timing period when any signal subsequent to said second of said signals is received before the expiration of said third timing period.

12. Apparatus in accordance with claim 6 wherein said one of said keys is indicative of a plurality of said characters and said responsive means is responsive to a pressure stroke applied across said one of said keys in a second direction for connecting said plurality of said first group of conductors to said plurality of said second group of conductors in a second sequential order and for generating signals indicative of a second one of said characters.

13. Apparatus in accordance with claim 6 wherein said responsive means comprises a group of switches, a plurality of said switches being operably associated with one of said keys, a pair of said conductors from said first and second groups being associated with each of said switches for establishing a connection therebetween, said switches being arranged for operation in a first sequence in response to said pressure stroke in said first direction for connecting said conductors in said first sequential order.

14. Apparatus in accordance with claim 13 including:

means for suppressing spurious signals caused by contact bounce when said switches are operated, said suppressing means including an integration circuit; and

means for controlling the duration and spacing of signals generated when said switches are operated.

15. A keyboard each character of which is keyed by a pressure stroke in a specified direction within an area designated by said character on the surface of said keyboard to produce a preselected sequence of signals in an output circuit representing said character, comprising, in combination:

a substrate having thereon a plurality of first contact members located in switching areas corresponding to said designated areas, and a plurality of first conductors each of which is connected to preselected ones of said first contact members;

an insulating spacer mounted on said substrate and having apertures therein aligned with said first contact members;

a resilient membrane mounted on said spacer and forming said surface of said keyboard and having said characters designated thereon, said membrane having on a major surface thereof a plurality of second contact members within said designated areas, said second contact members within a designated area being aligned with corresponding ones of said first contact members in a respective one of said switching areas through said apertures, and a plurality of second conductors each of which is connected to preselected ones of said second contact members, one of said signals being produced when one of said first conductors is connected to one of said second conductors, said membrane being adapted for movement through said apertures in response to said pressure stroke to connect said plurality of second contact members within said designated area with said corresponding ones of said first contact members within said respective switching area for connecting respective ones of said first conductors to respective ones of said second conductors, said first and second contact

members being arranged for sequential connection to produce said preselected sequence of signals.

16. A keyboard each character of which is keyed by a pressure stroke within an area defined by said character on the surface of said keyboard, said character being represented by signals generated by the connection of two first conductors with two second conductors in a specified sequence by said pressure stroke, comprising, in combination:

a substrate having thereon a plurality of said first conductors and a plurality of first contact members, first and second ones of said first contact members being respectively located within first and second portions of respective switching areas designated on said substrate, first and second ones of said first conductors being respectively connected to said first and second ones of said first contact members within said first and second portions of said switching area;

a spacer on said substrate having openings therethrough aligned with respective ones of said first contact members; and

a deformable membrane comprising said surface of said keyboard and having said defined areas thereon, said membrane having thereon a plurality of second contact members and a plurality of said second conductors, first and second ones of said second contact members being respectively located within first and second portions of said defined area, said first and second ones of said second contact members in said first and second portions of said defined area being respectively aligned through said openings with said first and second ones of said first contact members in said first and second portions of a corresponding one of said switching areas, first and second ones of said second conductors being respectively connected to said first and second ones of said second contact members within said first and second portions of said defined area, said membrane being adapted for movement through said openings in response to said pressure stroke to effect contact between said first and second ones of said second contact members within said defined area and said respective first and second ones of said first contact members within said corresponding switching area in a sequential order thereby connecting said first and second ones of said first conductors, respectively, to said first and second ones of said second conductors in said specified sequence to represent said character.

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