United States Patent [19]

Hendricks

[11] **3,886,335**

[45] **May 27, 1975**

[54] **COLLATED CABLE MATRIX SWITCH**

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[73] Assignee: **Industrial Electronics Engineers, Inc.,** Van Nuys, Calif.

[22] Filed: **Jan. 26, 1973**

[21] Appl. No.: **327,152**

[52] **U.S. Cl.** ..... **200/1 R;** 200/5 R; 200/5 A; 200/159 B; 340/365 R

[51] **Int. Cl.** **H01h 13/70;** G08c 9/00

[58] **Field of Search** ..... 200/1 R, 5 A, 159 B, 86 R, 200/86 A, 16 A, 166 PC, 11 D, 11 DA, 166 C, 292; 84/1.01, 1.04; 178/17 C; 235/145 R; 340/365 R, 365, A, 365 E, 200/262-270

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Primary Examiner—James R. Scott
Attorney, Agent, or Firm—Ellsworth R. Roston

[57] **ABSTRACT**

In a matrix of switches disposed in rows and columns, a plurality of first discrete conductors are deposited on the surface of a first backing member to extend in a first direction and a plurality of second discrete conductors are deposited on the surface of a second backing member to extend in a second direction. Dielectric spacing means is disposed between the first and second backing members to maintain the first and second conductors in a normally spaced relationship. The spacing means defines a plurality of openings each extending between an associated pair of the first and second conductors which define one of the switches. By pressing the associated pair of conductors into relative engagement through the associated opening in the spacing means, a signal on the associated first conductor is switched to the associated second conductor.

The second conductors can extend through a pair of the switches and can be bisected therebetween to increase the number of discrete switches in the matrix without increasing the number of conductors. A bar clamp provides an interface between the switches in the matrix and the electronics associated with the controlled operations.

A method for making the matrix of switches includes the steps of providing a spool for each of the backing members, the conductors, and the spacing means, and guiding the conductors and the spacing means in a spaced relationship onto the backing member. This process can be performed at high speed with inexpensive materials to significantly reduce the cpst of manufacturing the matrix of switches.

27 Claims, 24 Drawing Figures

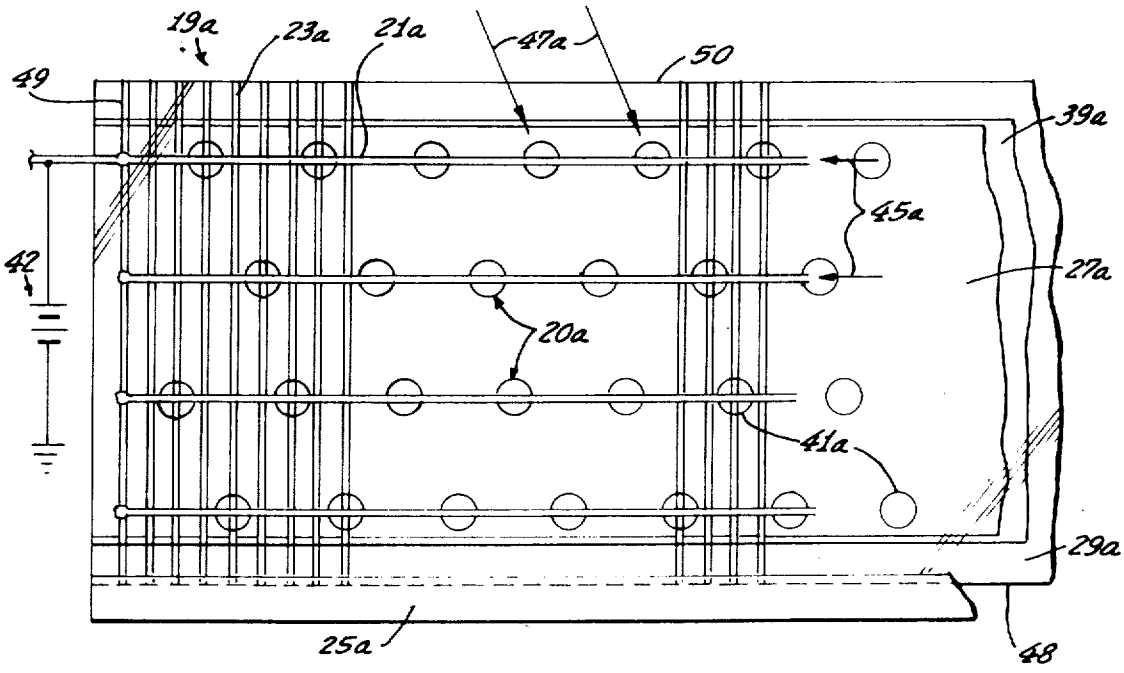


Fig. 1

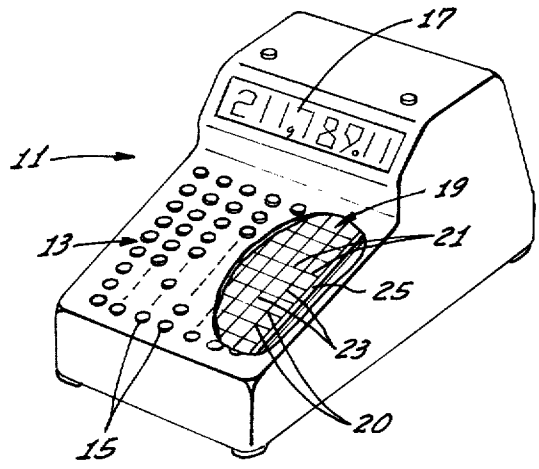


Fig. 3

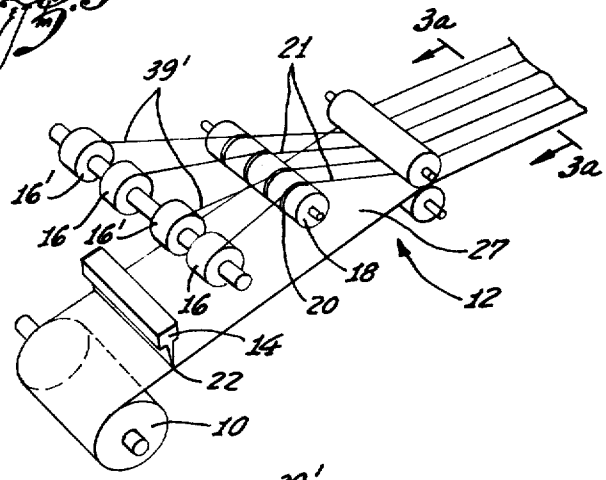


Fig. 2

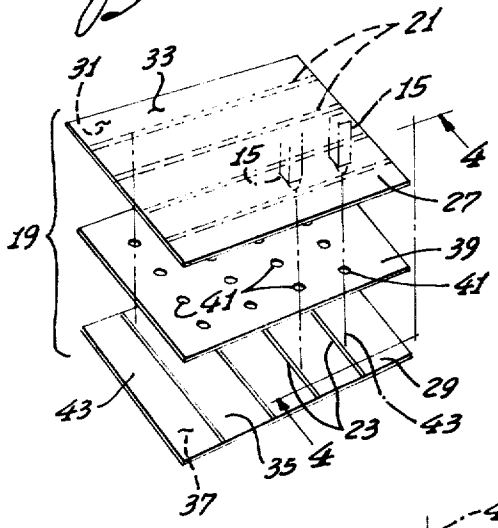


Fig. 3a

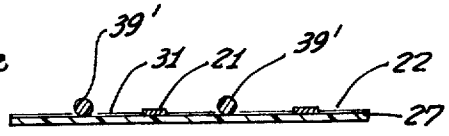
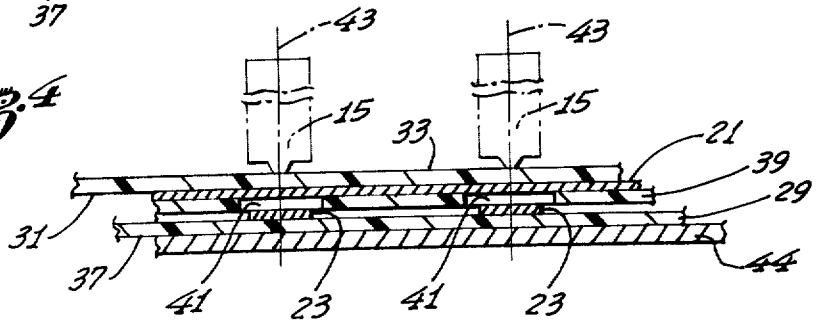


Fig. 4



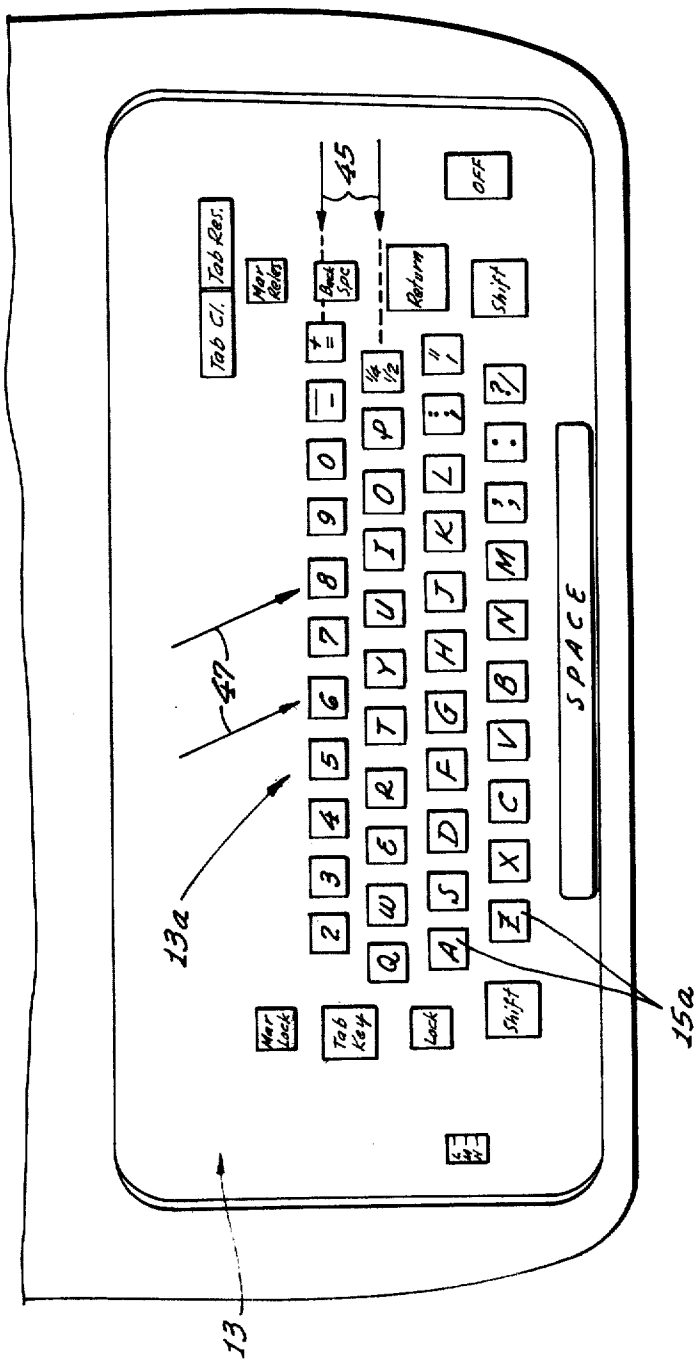

Tab Cl.
Tab Res.
Mar Rel.
Par Spc
Return
Shift
OFF
45
47
13a
SPACE
Mar Lock
Tab Key
Lock
Shift
15a
13

Fig. 5

FIG. 5A

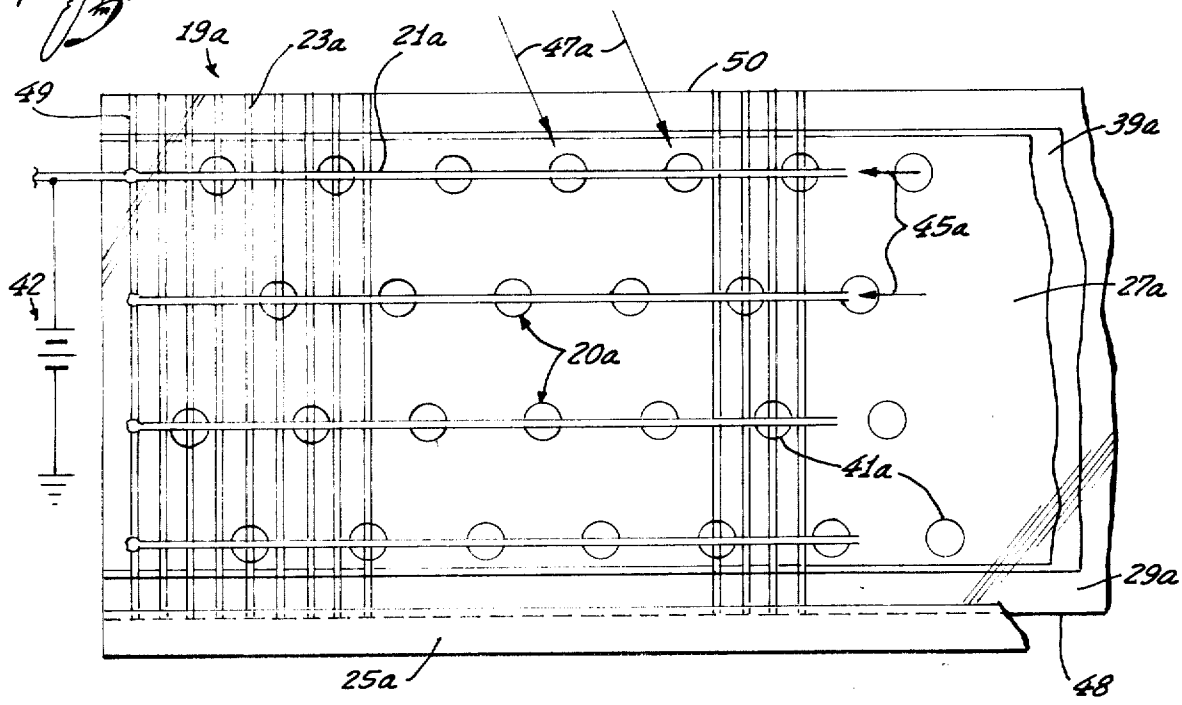
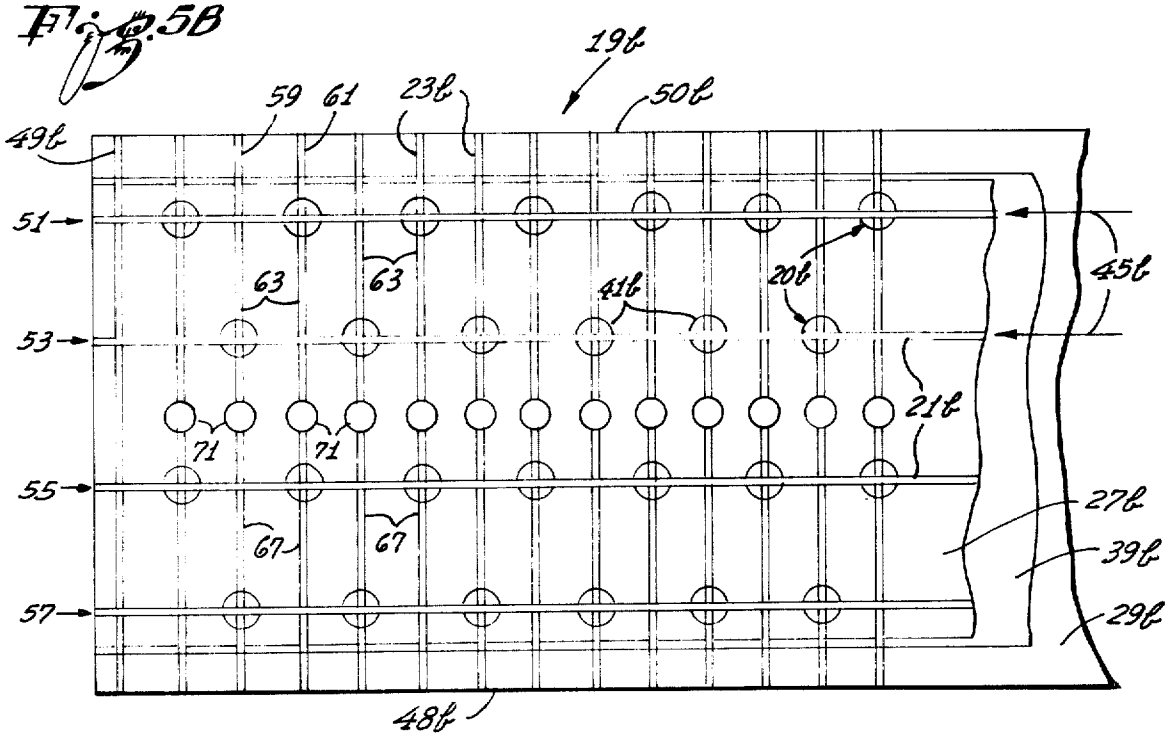

19a
23a
21a
47a
50
49
39a
45a
42
27a
20a
41a
29a
25a
48

FIG. 5B


19b
59
61
23b
50b
49b
51
63
63
41b
20b
45b
53
21b
71
71
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27b
67
67
39b
57
29b
48b

Fig. 6

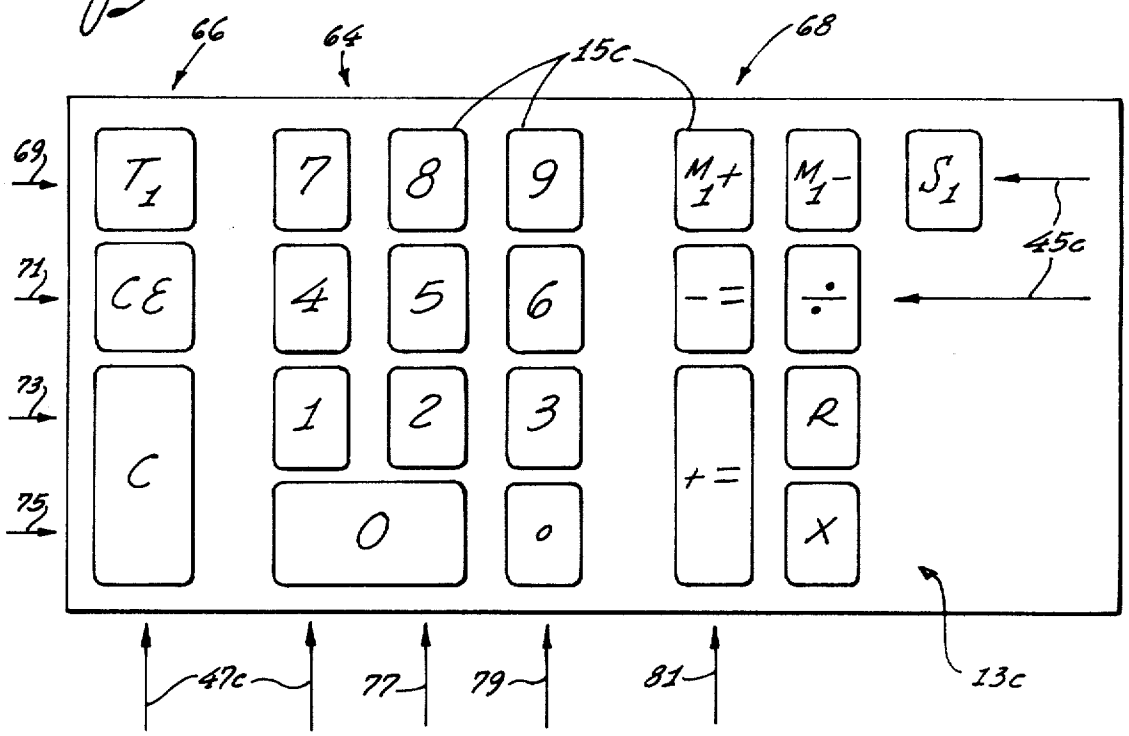

66
64
15c
68
69
71
73
75
T1
7
8
9
M1+
M1-
S1
45c
CE
4
5
6
-=
÷
C
1
2
3
R
+=
0
0
X
47c
77
79
81
13c

Fig. 6A

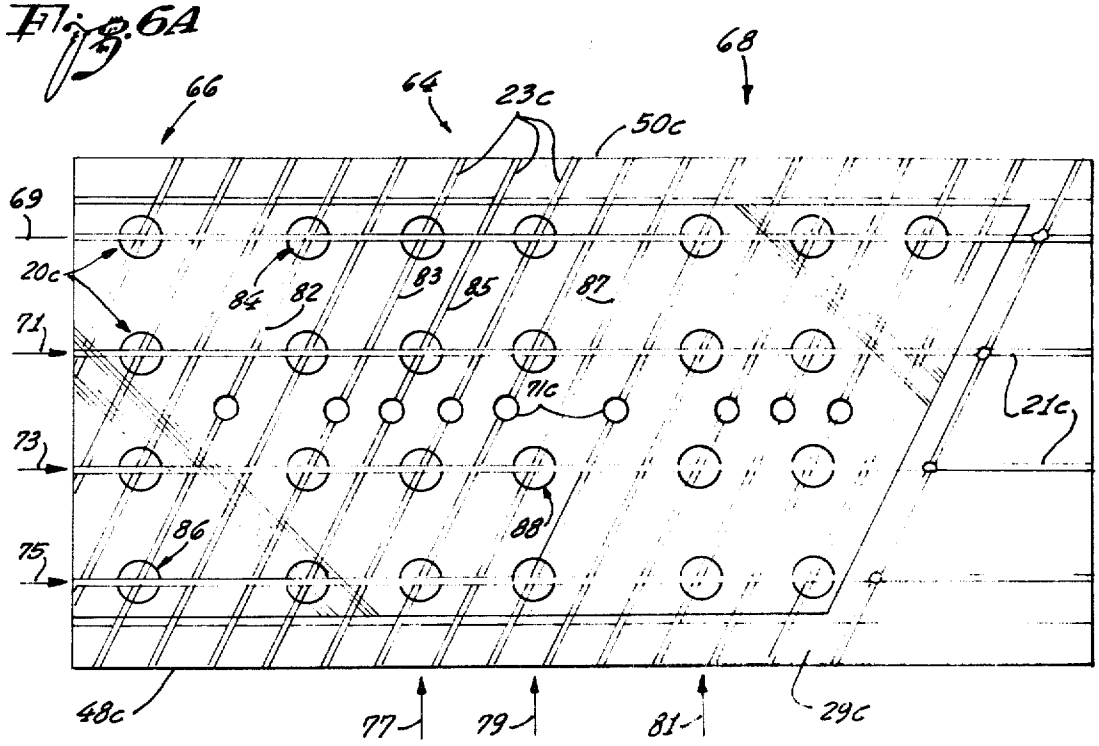
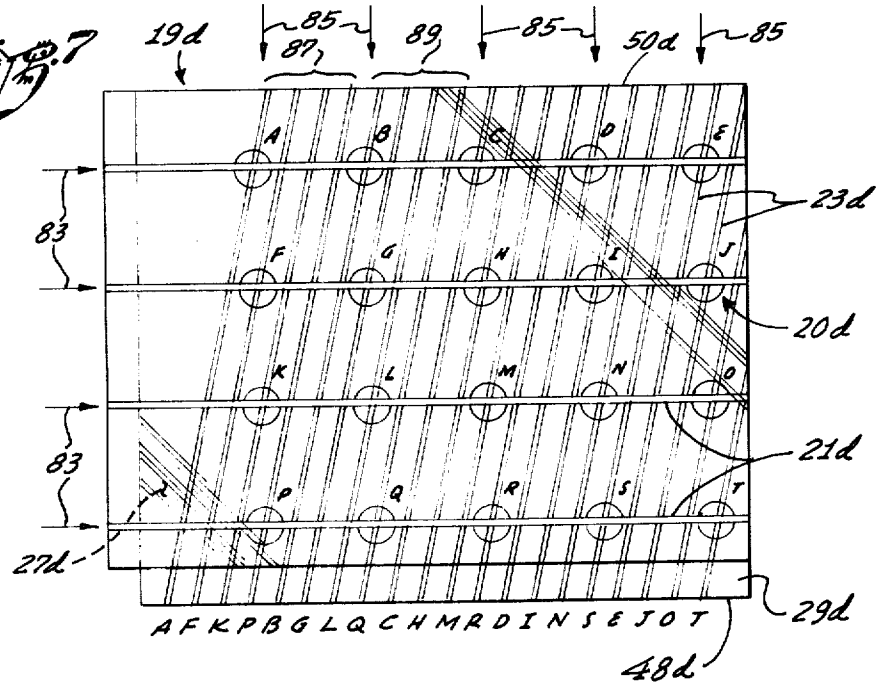

68
66
64
23c
50c
69
20c
84
82
83
85
87
71
71c
21c
73
88
75
86
48c
77
79
81
29c

Fig. 7


19d
85
87
89
85
50d
85
A
B
C
D
E
23d
83
F
G
H
I
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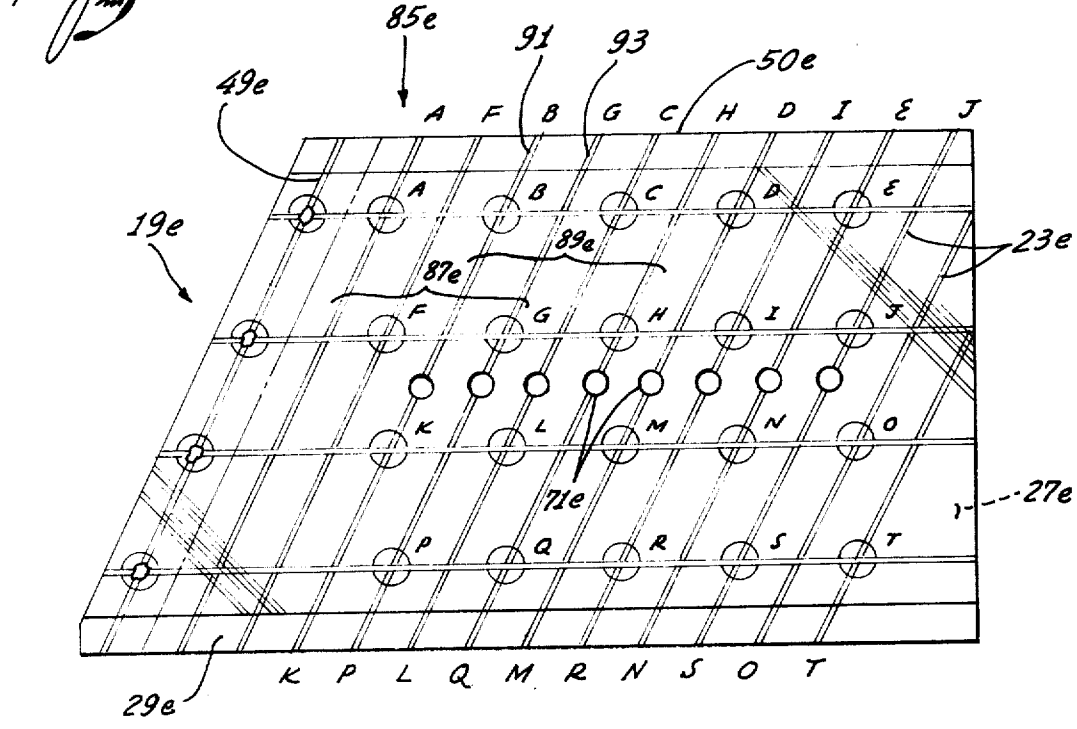
20d
K
L
M
N
O
21d
83
P
Q
R
S
T
27d
29d
A F K P B G L Q C H M R D I N S E J O T
48d

Fig. 7A


85e
91
93
50e
49e
A F B G C H D I E J
19e
A
B
C
D
E
23e
89e
87e
F
G
H
I
J
K
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71e
27e
P
Q
R
S
T
29e
K P L Q M R N S O T

Fig. 7B

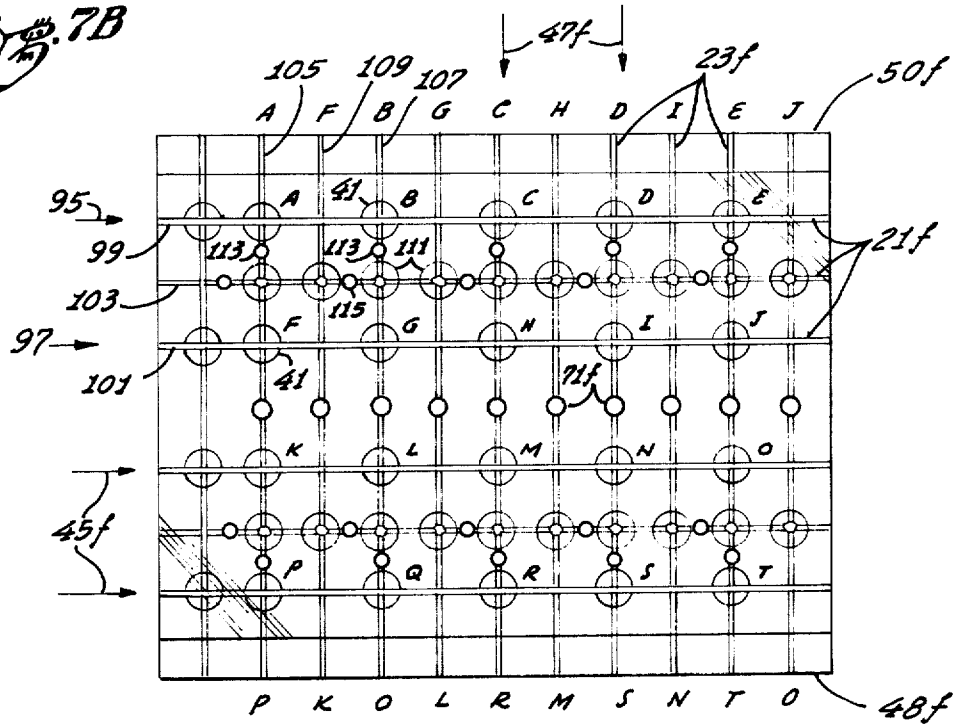


Fig. 9

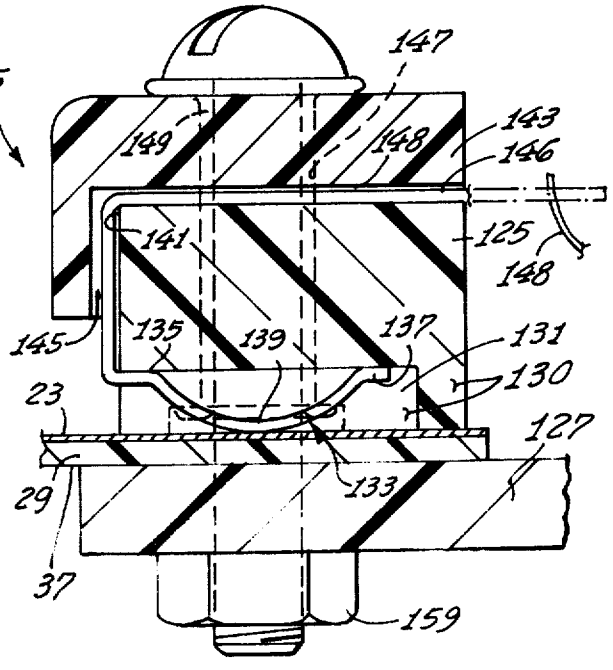


Fig. 10

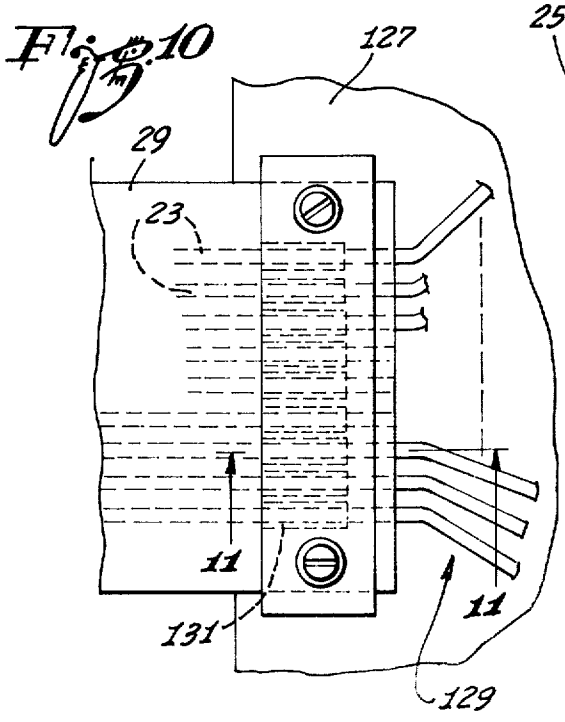


Fig. 8

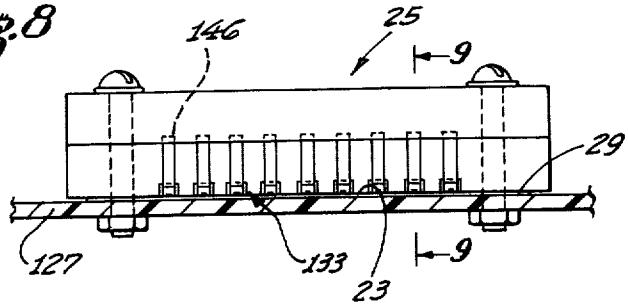


Fig. 11

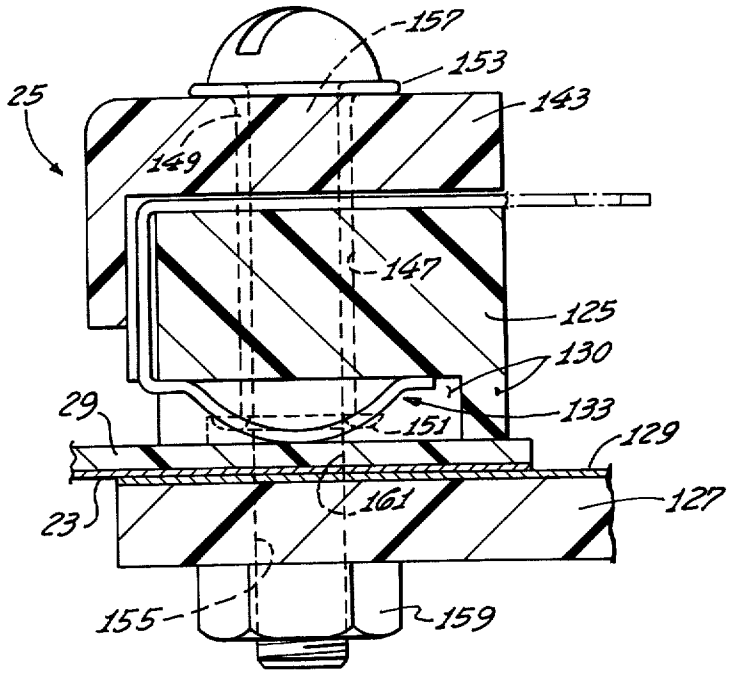
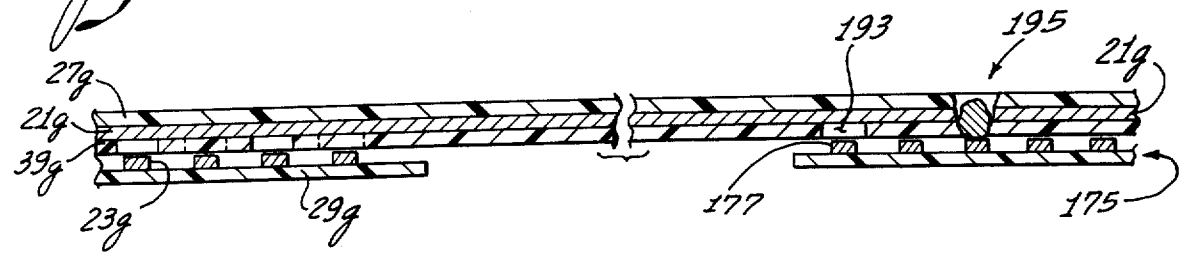


Fig. 13



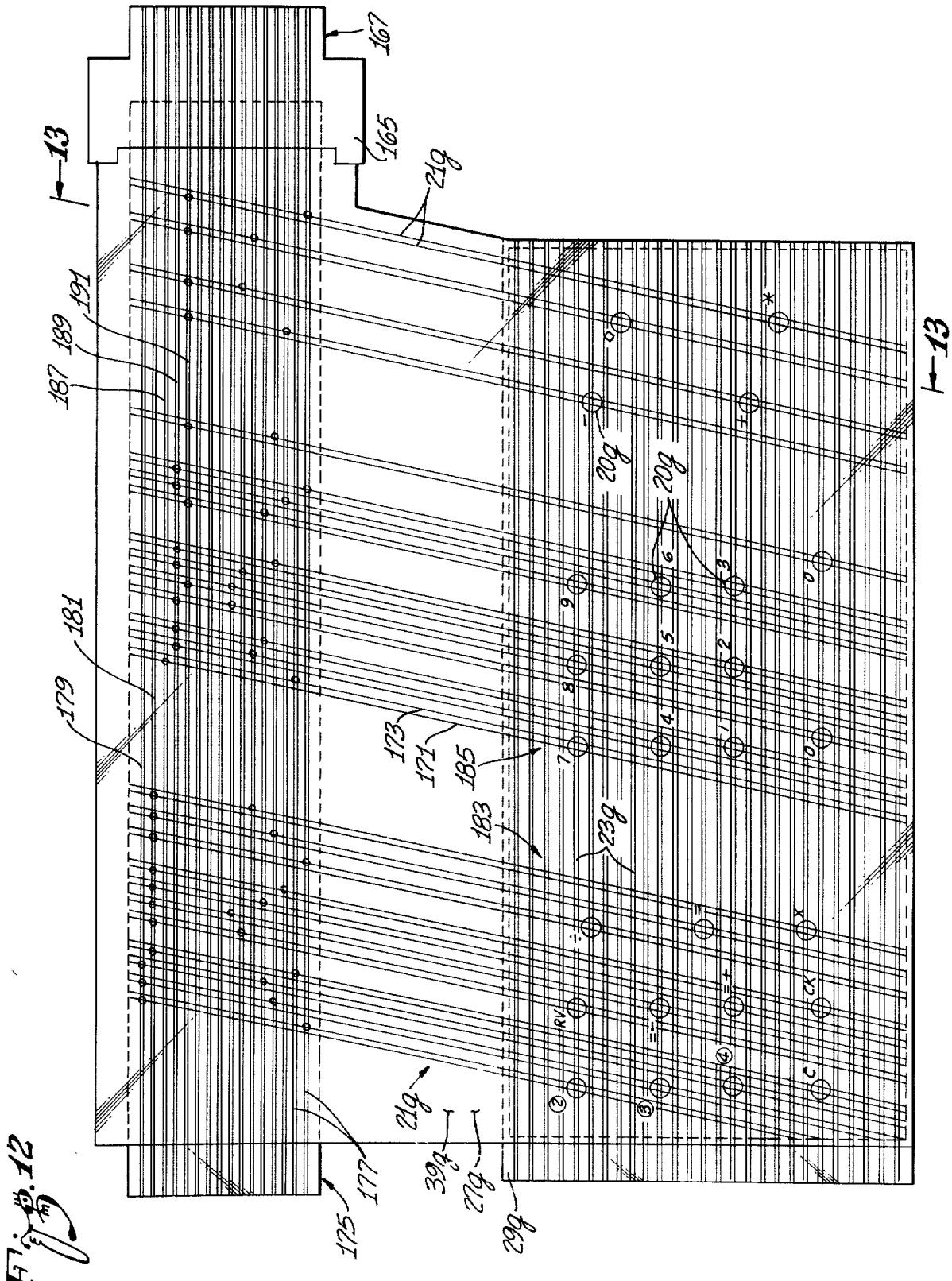

13
13
167
165
219
191
189
187
181
179
173
171
185
183
239
219
177
175
219
39
279
299

Fig. 12

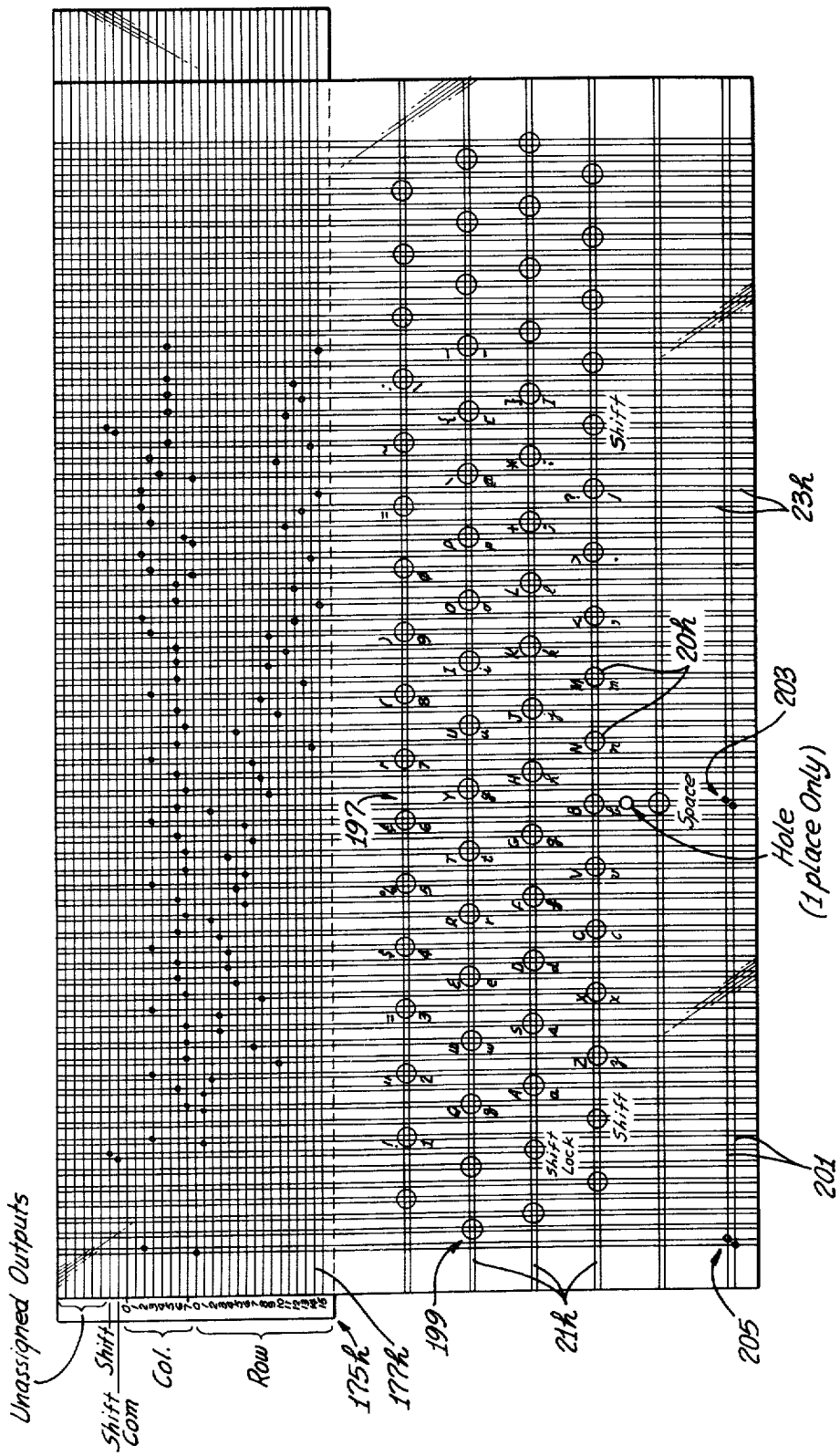

Unassigned Outputs
Shift Com
Shift
Col.
Row
175k
177k
199
21k
205
201
Shift
Shift Lock
Shift
197
20k
203
Space
Hole
(1 place Only)
23k

Fig. 14

Fig. 15

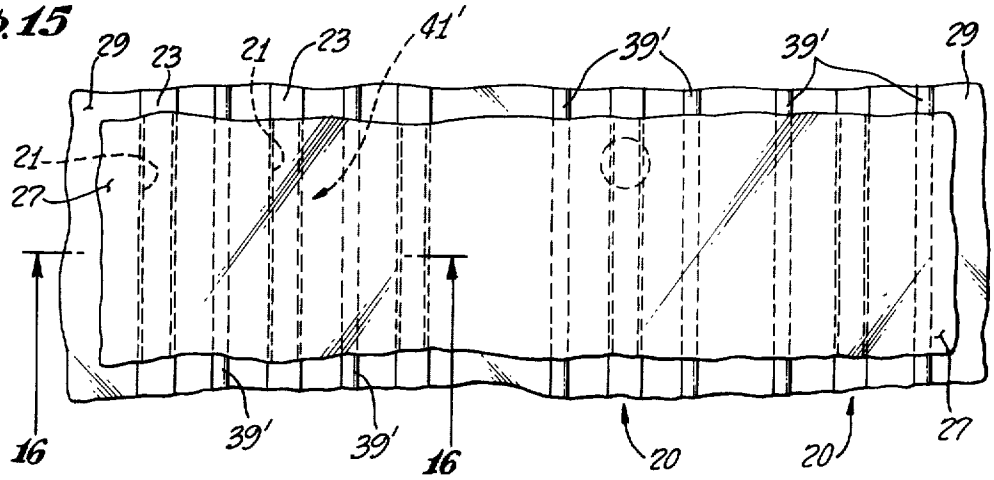


Fig. 16

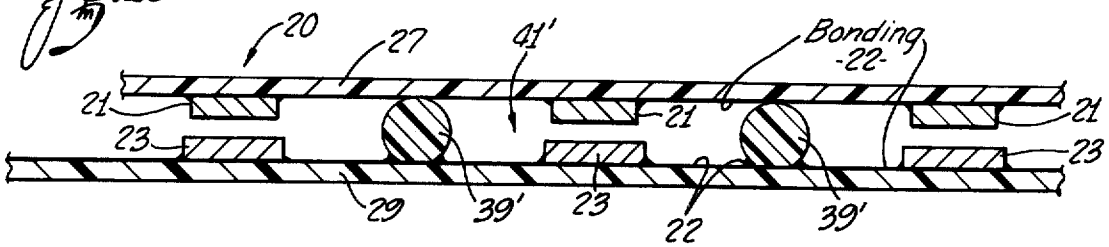


Fig. 17

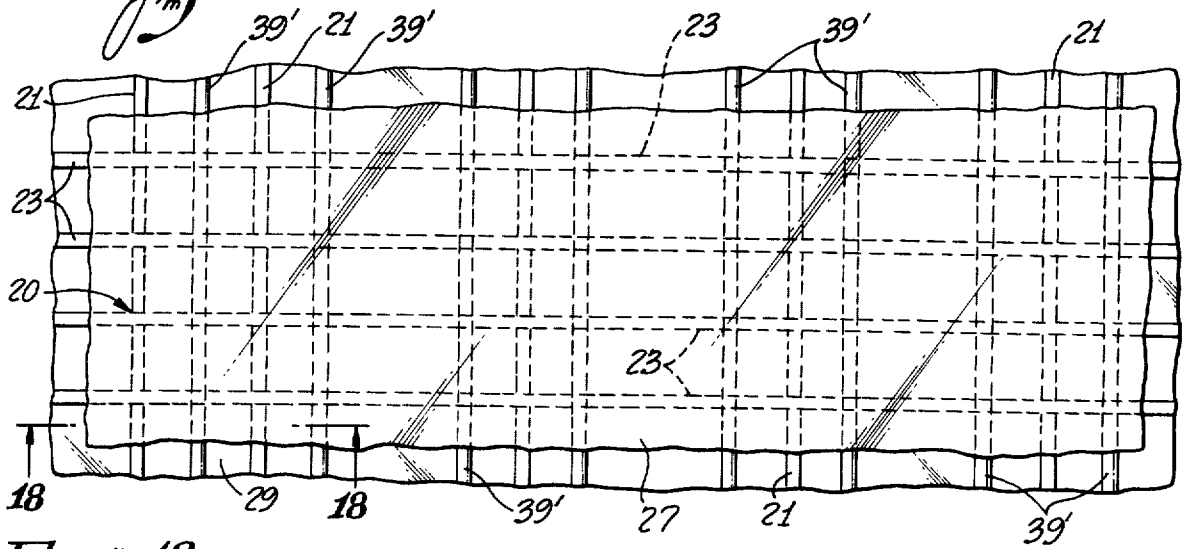
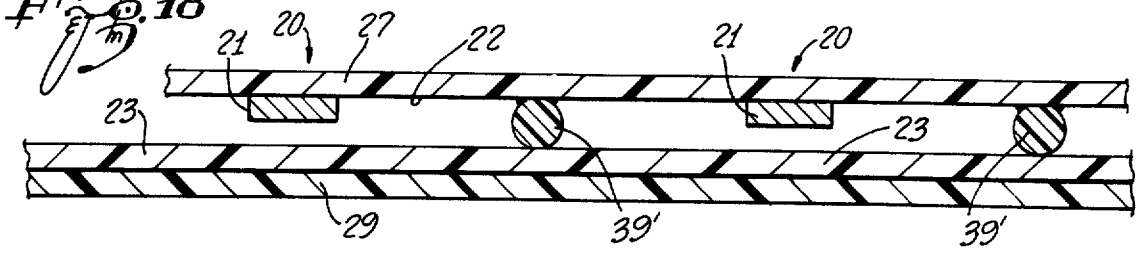


Fig. 18



COLLATED CABLE MATRIX SWITCH

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates generally to matrix switches which are particularly adaptable to alphanumeric keyboards, and a method for manufacturing the matrix switches at a relatively low price per switch.

2. Description of Prior Art

It has been desirable to provide an alphanumeric keyboard, such as those commonly used with typewriters, adding machines, and computer input terminals, with a matrix switch including a separate switch for each of the keys on the alpha-numeric keyboard. The matrix of switches has permitted electrical control of the particular operation with a resulting increase in speed and efficiency.

The switching matrices of the prior art have been manufactured by elaborate and time-consuming processes. This has made electrically actuated control of the particular operation prohibitively expensive for some applications. For example, the switching matrices of the prior art have relied upon electro-chemical processes, such as metal deposition and etching processes, to provide circuit conductors and switch contact surfaces. These processes have included numerous expensive steps so that the resulting switching matrices have had a relatively high cost per switch.

Copending application Ser. No. 163,399, and now abandoned assigned of record to the assignee of record of the present application, discloses and claims a flexible switch having a first conductor disposed on the surface of the first backing member and a second conductor disposed on the surface of a second backing member. A spacing member which normally separates the first and second conductors is provided with an opening extending therebetween so that the first and second conductors can be moved into relative engagement through the opening. This enables the signal on the first conductor to be switched to the second conductor. The backing members and the spacing members have been formed from translucent materials so that the switch can be backlighted to illuminate indicia on the switch.

Also included in the prior art are collated cables which typically are used to interconnect remote electronic assemblies. The collated cables are typically manufactured by providing two spools of a first and second backing material and a spool of wire for each of the conductors desired in the cable. These wires can be fed across guide means so that the conductors are sandwiched between the first and second backing members in an electrically insulated relationship to one another. The backing members can be bonded together by heat and pressure to hermetically seal the structure. This process for manufacturing collated cable can run at speeds up to 40 ft. per minute and at costs significantly less than the etching and deposition processes.

SUMMARY OF THE INVENTION

The low cost process for manufacturing collated cable can provide a backing member having a plurality of electrically discrete conductors disposed thereon to extend in a first direction. In a similar manner, a second backing member can be provided and second electrically discrete conductors disposed thereon to extend in a second direction transverse to the first direction. The first and second conductors can be maintained in a normally spaced relationship by a dielectric spacing means disposed in contiguous relationship with the first and second backing members. The dielectric spacing means can be provided with a plurality of openings each extending between an associated pair of the first and second conductors. The openings will enable each of the associated first and second conductors to be moved into relative engagement through the associated opening to switch a signal from the associated first conductor to the associated second conductor. In this manner a switching matrix can be provided with a switch at the intersection of each of the first conductors and each of the second conductors.

The switches in the matrix can be disposed to accommodate a particular alphanumeric keyboard so that each of the keys on the keyboard can force one of the first conductors into engagement with the associated second conductor. The number of switches per conductor can be increased by extending the second conductors through a pair of the switches and bisecting the second conductor between the switches. In this manner, two discrete switches can be defined at the intersection of two first conductors and a single second conductor.

The process for manufacturing collated cables can be used advantageously to assemble the backing members and the associated conductors. Since this major step in the process of forming the matrix switch can be performed at a high rate of speed, the resultant matrix switch can be manufactured at a relatively low cost. Furthermore, the collated cables can be disposed on translucent backing members so that the individual switches can be backlighted to illuminate the indicia of the keyboard. The provision of low-cost switching matrices will enable the high speed and efficiency of electrically controlled operations to be economically available for a significant number of applications.

The dielectric spacing means can have a generally planar configuration with a plurality of apertures therein. Alternatively, the spacing means can comprise a plurality of longitudinal members extending in one of the first and second directions and cooperating with each other to define the openings. These longitudinal spacing members can be wound on spools and guided onto the first backing member simultaneously with the first conductors. Thus, the high-speed collating process can provide the spacing means as well as the conductors.

These and other features and advantages of the invention will become more apparent with a detailed description of the invention in conjunction with the associated drawings.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view partially in phantom of an adding machine including a switching matrix;

FIG. 2 is an assembled view of the switching matrix shown in FIG. 1;

FIG. 3 is a perspective view of an apparatus which can be used to manufacture the switching matrix;

FIG. 3A is a cross-sectional view of a portion of the switching matrix taken on line 3*a*—3*a* of FIG. 3;

FIG. 4 is a cross-sectional view of the switching matrix taken on line 4—4 of FIG. 2;

FIG. 5 is a plan view of the keyboard of a standard typewriter;

FIG. 5A is an embodiment of a switching matrix which can be used in conjunction with the typewriter keyboard shown in FIG. 5;

FIG. 5B is a further embodiment of a matrix switch which can be used in conjunction with the keyboard shown in FIG. 5;

FIG. 6 is a plan view of a standard adding machine keyboard;

FIG. 6A is an embodiment of a switching matrix which can be used in conjunction with the keyboard shown in FIG. 6;

FIG. 7 is one embodiment of a switching matrix which can be used with a keyboard having keys spaced in symmetrical rows and columns;

FIG. 7A is an additional embodiment of a matrix switch which can be used with a keyboard having keys spaced in symmetrical rows and columns;

FIG. 7B is a further embodiment of a switching matrix which can be used with a keyboard having keys spaced in symmetrical rows and columns;

FIG. 8 is a front elevational view of a bar clamp for terminating a matrix switch;

FIG. 9 is a cross-sectional view of the bar clamp taken on line 9—9 of FIG. 8;

FIG. 10 is a plan view of the bar clamp for terminating the matrix switch on a printed circuit board;

FIG. 11 is a cross-sectional view of the bar clamp taken on line 11—11 of FIG. 10.

FIG. 12 is a plan view of a further embodiment of the matrix switch used in conjunction with an adding machine keyboard;

FIG. 13 is a cross-sectional view of the matrix switch taken on line 13—13 of FIG. 12.

FIG. 14 is a plan view of an additional embodiment of the matrix switch used in conjunction with a typewriter keyboard;

FIG. 15 is a plan view of an additional embodiment of the matrix switch including longitudinal spacing members;

FIG. 16 is a cross-sectional view of the matrix switch taken on line 16—16 of FIG. 15;

FIG. 17 is a plan view of still a further embodiment of the matrix switch including the longitudinal spacing members; and

FIG. 18 is a cross-sectional view of the matrix switch taken on line 18—18 of FIG. 17.

DESCRIPTION OF PREFERRED EMBODIMENT

An adding machine is shown generally in FIG. 1 and designated by the reference numeral 11. The adding machine 11 has a keyboard 13 including a plurality of keys 15 arranged in rows and columns. By selectively operating the keys 15, the operation of the adding machine 11 can be controlled to provide a desired output which is displayed, for example, on a display screen 17.

It is often desirable that the keys 15 on the keyboard 13 respectively actuate an individual electrical switch in order to permit electrical control of the operation. Electrical control is particularly desirable since it significantly increases the speed and accuracy with which the operation can be performed.

Electrical control can be accomplished by means of a switching matrix such as that shown generally at 19. The switching matrix 19, which typically includes a switch 20 for each of the keys 15, preferably is disposed in proximity to the keyboard 13 so that a slight pressure on a particular one of the keys 15 will actuate the associated switch 20.

In the preferred embodiment, the switching matrix 19 includes a plurality of first electrically discrete conductors 21 extending in a first direction, and a plurality of second electrically discrete conductors 23 which may extend in a second direction transverse to the first direction. A bar clamp 25 can provide means for individually engaging the second conductors 23 to provide an interface between the switches 20 and any electronics (not shown) associated with the controlled operation.

It will be apparent to those skilled in the art that the adding machine 11 is merely representative of many operations wherein the benefits of electrical control can be achieved by means of the switching matrix 19. For example, it will be obvious that the switching matrix 19 can be advantageously used with other alphanumeric keyboards, such as those associated with typewriters and computer input terminals. Furthermore, although the adding machine 11 is illustrated with a keyboard 13 wherein the keys 15 are disposed in symmetrically spaced rows and columns, the concepts of the invention can be embodied to accommodate nonuniform keyboards.

The switches 20 forming the switching matrix 19 can be of the type disclosed and claimed in copending application Ser. No. 163,399 and assigned of record to the assignee of record of the present application. Thus, with reference to FIG. 2, it will be noted that the switching matrix 19 can include a first backing member 27 defined by an inner surface 31 and an outer surface 33, and a second backing member 29 defined by an inner surface 35 and an outer surface 37. The first conductors 21 are preferably aligned on the inner surface 31 of the backing member 27 so that they are at least partially exposed in an electrically insulated relationship to one another. For example, the first conductors 21 can be adhered to the inner surface 31 so that they extend substantially parallel to one another in a first direction. Similarly, the second conductors 23 can be adhered to the inner surface 35 so that they are exposed in an electrically insulated relationship to one another, and generally extend in a second direction different than the first direction.

The first and second backing members 27 and 29, respectively, can be made from a suitable transparent or translucent material such as the polyester designated by the tradename Mylar and manufactured by the DuPont Corporation. This material is particularly desirable since it is highly resistant to solvents which may be advantageously used to clean the conductors 21 and 23. The thickness of the backing members 27 and 29 may range from 0.003 to 0.015 inches with a thickness, such as 0.005 inches preferred.

Dielectric spacing means can be sandwiched between the inner surfaces 31 and 35 of the first and second backing members 27 and 29, respectively, to maintain the conductors 21 and 23 in a normally spaced relationship. In one preferred embodiment, the spacing means comprises a spacing member 39 having a generally planar configuration and portions thereof defining a plurality of apertures 41. Each of the apertures 41 typically circumscribes an imaginary line, such as the dotted line 43 which extends between an associated one of the first conductors 21 and an associated one of the second conductors 23. Preferably, the dotted line

43 is the shortest line which connects the associated pair of the first and second conductors 21 and 23, in which case it is substantially perpendicular to the first and second backing members 27 and 29, respectively.

The spacing member 39 can be formed from any suitable dielectric material to maintain the first conductors in a normally electrically insulated relationship with respect to the second conductors 23. In a preferred embodiment, the spacing member is formed from the polytetrafluoroethylene material marketed by DuPont under the tradename Teflon. It is within the skill of those in the art to form the spacing member 39 of other dielectric materials which may provide additional advantages under some circumstances. For example, a translucent material, such as Mylar, can be advantageously used for the planar spacing member 39 if it is desired to backlight the switches 20 of the switching matrix 19.

The first and second conductors 21 and 23, respectively, may have a circular cross section with a diameter as small as 0.002 inches or as large as 0.020 inches. However, in the preferred embodiment, the conductors 21 and 23 are rectangular in cross section having a thickness such as 0.003 inches and a width such as 0.015 inches. The conductors 21 and 23 can include a suitable material, such as copper or aluminum, having a high electrical conductivity and they may be plated with a material, such as gold or rhodium, to enhance the switching characteristics of the switches 20. To minimize the plating area, rectangular cross-sectional dimensions for the conductors 21 and 23 are preferably less than 0.005 and 0.030 inches.

In an embodiment where the first and second conductors 21 and 23, respectively, have a width of 0.125 inches, the apertures 41 in the spacing member 39 may be provided with a diameter such as 0.25 inches. These dimensions have been particularly desirable for maintaining the associated first and second conductors 21 and 23 in a normally spaced relationship while enabling them to be pressed into relative engagement through the associated aperture 41. It is this relative engagement of the associated first and second conductors 21 and 23 which provides the switching characteristics for an individual one of the switches 20 in the switching matrix 19.

This preferred operation of the switching matrix 19 can be more easily understood with reference to FIG. 4 wherein one of the first conductors 21 is illustrated to extend in a first direction across the page of the drawings and some of the second conductors 23 are illustrated to extend in a second direction into the page of the drawings. The apertures 41 are defined in the dielectric spacing member 39 between the associated first and second conductors 21 and 23 to extend coaxially with the dotted lines 43. In this embodiment, the keys 15 are individually disposed for movement along one of the dotted lines 43 to engage the outer surface 33 of the first backing member 27, and to force the associated first conductors 21 through the associated aperture 41 to electrically engage the associated second conductor 23. It can be appreciated that by operation of the keys 15, the signal present on the associated first conductors 21 can be switched to the associated second conductors 23 so that the signals present on the second conductors 23 can activate the electronics (not shown) of the operation. In this manner the selective operation of the keys 15 can provide electrical control of the operation, such as the adding machine 11.

In the preferred embodiment, a relatively rigid supporting member 44 is disposed to engage the outer surface 37 of the second backing member 29 to provide support for the switching matrix 19 so that the second conductors 23 can maintain a substantially fixed position. It will be appreciated by those skilled in the art that the second conductors 23 can be moved to engage relatively stationary first conductors, or alternatively, the associated first and second conductors 21 and 23, respectively, can be simultaneously moved into engagement through the associated aperture 41.

Referring now to FIGS. 15 and 16, it will be noted that the first conductors 21 and the second conductors 23 can extend in substantially the same direction. In fact, a particular pair of the first and second conductors 21 and 23, respectively, which form a single switch 20, can be aligned in a plane substantially perpendicular to the plane of the matrix switch 19, i.e., the plane of the page. In such an embodiment, the pressing of one of the first conductors 21 substantially anywhere along the length thereof will move the pressed conductor 21 into electrical contact with the associated second conductor 23.

Although the first and second conductors 21 and 23, respectively, can have any cross-sectional configuration, it may be desirable that they have rectangular cross-sectional configurations to maximize the area of contact at a particular point of contact. It may be further desirable that the second conductors 23 have a greater width than the first conductors 21 in order to facilitate their alignment during the construction of the switch.

As best illustrated in FIG. 16, the spacing means of the matrix switch 19 can include a plurality of longitudinal spacing members 39' which typically extend in the same direction as the first conductors 21 and which define an opening 41' in proximity to each of the switches 20. Although the spacing members 39' can have any cross-sectional configuration, their dimension between the first and second backing members 27 and 29, respectively, should be sufficient to provide the desired spacing between the first and second conductors 21 and 23, respectively. Also, the distance between the longitudinal spacing members 39' and the adjacent switches 20 should be sufficient to enable the conductors 21 and 23 to be moved into electrical contact through the openings 41'.

In a preferred embodiment which includes polyester backing members 27 and 29 having a thickness of 0.004 inches, the conductors 21 and 23 have a width of 0.030 inches, and a thickness of 0.003 inches. In this embodiment the longitudinal spacing members 39' have a generally circular cross section providing a dimension between the first and second backing members 27 and 29, respectively, of approximately 0.009 inches. This provides a desired spacing of 0.003 inches between the associated first and second conductors 21 and 23, respectively. An adjacent pair of the spacing members 39' can be disposed equidistant from the associated pair of conductors 21 and 23 and spaced from each other a distance within the preferred range of 0.100 inches to 0.250 inches.

It will be noted that if the switches 20 are sufficiently close, as at the left side of FIG. 15, they can be alternated with the spacing members 39' to maintain the de-

sired spacing between the first and second conductors **21** and **23** in the switches **20.** However, if the switches **20** are spaced a significant distance, as at the right side of FIG. **15,** it may be desirable to provide a spacing member **39'** on each side of an associated switch **20.** In the latter case, there would typically be two spacing members **39'** between an adjacent pair of the switches **20.**

A further embodiment of the matrix switch **19** can be provided in accordance with FIGS. **17** and **18** wherein the longitudinal spacing members **39'** extend in a common direction with the first conductors **21** but intersect the second conductors **23.** The switches **20** are defined at the points of intersection between the first and second conductors **21** and **23,** respectively. It will be apparent that in such an embodiment the adjacent switches **20,** which are associated with a particular one of the first conductors **21,** may not be separated by any spacing member **39'.** Therefore, it may be desirable to separate the second conductors **23** a distance sufficient to insure that the activation of a single switch **20** does not also activate the adjacent switch **20,** which is associated with the same first conductor **21.** Since the adjacent switches **20** associated with a particular one of the second conductors **23** will typically be separated by one of the spacing members **39',** the first conductors **21** can be provided with any suitable spacing.

In this embodiment wherein the first and second conductors **21** and **23,** respectively, are transverse to each other, the spacing members **39'** are generally supported by the second conductors **23.** Thus, the cross-sectional thickness of the spacing members **39'** can be substantially equal to the thickness of the first conductors **21** plus the desired spacing distance between the first and second conductors **21** and **23,** respectively.

Since the longitudinal spacing members **39'** do not directly contact both the first conductors **21** and the second conductors **23,** their dielectric characteristics may not be as important as those of the planar spacing member **39.** However, in the preferred embodiment, the longitudinal spacing members **39'** are formed from polyester filaments which have relatively high electrical insulating properties.

The embodiments of the matrix switch **19,** which include the longitudinal spacing members **39',** are particularly advantageous since they eliminate the expense of a separate planar spacing member **39** and also the cost of a tool which would typically be used to punch the apertures **41** in the spacing member **39.** The embodiments of FIGS. **15** through **18** are also desirable since they significantly reduce the quality control problems associated with providing apertures **41** which are free of burrs. In some cases, these burrs can increase the operating force of an associated switch **20.**

In a preferred process, the first conductors **21** can be disposed on the inner surface **31** of the first backing member **27** are illustrated in FIG. **3.** The first backing member **27** can be disposed on a roll **10** and fed between a pair of rollers shown generally at **12.** An adhesive container **14** can be disposed between the roll **10** and the rollers **12** to deposit a suitable bonding agent **22** on the inner surface **31** of the first backing member **27.** In a preferred method, the first backing member **27** is purchased with a temperature-sensitive adhesive precoated thereon. A typical commercial product of this type is manufactured by Circuit Materials Company and designated as CMC-**153** polyester adhesive.

The first conductors **21** can be provided on the respective spools **16** to engage a guide roller **18** and to pass between the rollers **12** in contiguous relationship with the backing member **27.** The guide roller **18** can be of the type including a plurality of circumferential grooves **20** axially spaced on the surface of the guide roller **18.** Each of the first conductors **21** can be threaded through one of the grooves **20** so that the first conductors **21** are maintained in a spaced relationship, such as a parallel relationship, as they pass between the rollers **12** to engage the adhesive **22** on the first backing member **27.** The rollers **12** exert a pressure on the first conductors **21** and the first backing member **27** to provide them with a fixed relationship.

The bonding agent **22** can be a curable adhesive such as that marketed by General Mills Chemical Company under the tradename VERSALON. Such an adhesive can be partially cured prior to engaging the first conductors **21** and fully cured after the first conductors **21** have been deposited on the first backing member **27.** The rollers **12** can be heated to aid in the curing of the adhesive **22.** The above described process, which can be used to collate not only the first conductors **21** but also the second conductors **23,** is particularly advantageous since the conductors can be collated at rates of up to 40 feet per minute. Thus, major steps in the formation of the matrix switch **19** can be preformed at a high speed and a relatively low cost.

This preferred method provides even further advantages for those embodiments of the matrix switch **19** which include the longitudinal spacing members **39'.** For example, the spools **16** containing the conductors **21** can be alternated with spools **16'** containing the longitudinal filaments **39'.** Then the filaments **39'** can be guided through the corresponding grooves **26** so that the conductors **21** and the filaments **39'** are simultaneously and automatically deposited on the backing member **27.** The resulting combination is shown in cross section in FIG. **3***a*.

This preferred method will offer an even greater cost reduction for those particular embodiments including the spacing members **39'** since a separate member **39** need not be provided, punched, and aligned. It is also apparent that the embodiments including the longitudinal spacing members **39'** permit a greater flexibility in design. Thus, the cost of collating a different cable including the spacing members **39'** is significantly less than the cost of providing different tooling to punch the apertures **41** in the planar spacing member **39.**

The concepts of the switching matrix **19** can be embodied to accommodate the patterns of many different keyboards. In the following detailed description of some of these embodiments, elements which have characteristics and functions similar to the elements in preceding embodiments will be provided with similar reference numerals followed by a lower case letter corresponding to the particular embodiment. The lower case letters will be chosen so that consecutive letters correspond to consecutive embodiments. For example, a matrix switch **19** can be embodied to accommodate a conventional typewriter having a keyboard **13***a*, such as that shown generally in FIG. **5.** It will be noted that the keys **15***a* of the keyboard **13***a* extend in a plurality of rows **45** and a plurality of columns **47** having a first angular relationship with the rows **45.**

A matrix switch **19***a*, shown in FIG. **5A,** can be used with the keyboard **13***a* of a standard typewriter. Prefer-

ably each of the switches **20***a* is disposed to be operated when an associated key **15***a* (FIG. 5) is depressed. For example, the switches **20***a* can be disposed beneath the keys **15***a* so that the switches **20***a* are also arranged in the rows **45***a* and the columns **47***a*. To accommodate such a keyboard, the first conductors **21***a* can extend in a first direction, such as the direction of the rows **45***a*, and the second conductors **23***a* can extend in a second direction different than the first direction. This will provide the second conductors **23** with a second angular relationship with respect to the rows **45***a*. In this particular embodiment, each of the first conductors **21** is associated with an entire row **45***a* of the keys **15***a* while each of the second conductors **23***a* is associated with only one of the rows **45***a*. This provides each of the switches **20***a* with discrete characteristics so that the operation of one of the keys **15***a* activates only one of the switches **20***a*.

A signal, such as that provided by a source of operating potential **42**, can be introduced to each of the first conductors **21***a* so that the operation of an individual switch **20***a* in the matrix **19***a* will switch the operating potential **42** to the associated one of the second conductors **23***a*. One method of introducing the operating potential **42** to the first conductors **21***a* is to include among the second conductors **23***a* a particular conductor **49** which preferably does not extend through any of the switches **20***a*. The particular conductor **49** can be soldered or welded to each of the first conductors **21***a* so that a signal introduced to one of the first conductors **21***a* is introduced to all of the first conductors **21***a*. The welds or solder joints can be made through holes (not shown but similar to the apertures **41***a*) in the spacing member **39***a* or, alternatively, the spacing member **39***a* can be cut short so that the first conductors **21***a* are exposed to the particular second conductor. Of course, signals can also be introduced to the first conductors **21** by a bar clamp similar to the bar clamp **25** terminating the second conductors **23.**

The second backing member **29***a* can include a first edge **48** and a second edge **50** between which the second conductors **23***a* extend. At least one of the first and second edges **48** and **50**, respectively, can extend a distance such as 0.25 inches beyond the first backing member **27** and the dielectric spacer **39***a* so that the second conductors **23***a* are exposed on the extended edge. Each of the extended edges **48** and **50** can register with one of the bar clamps **25***a* (FIG. **1**) to provide an interface between the second conductors **23***a* and the electronics of the typewriter (not shown). In the preferred embodiment only the first edge **48** is extended; however, the second edge **50** can also be extended if redundant termination of the second conductors **23***a* is desired.

A standard typewriter keyboard **13***a* (FIG. **5**) can also be accommodated by the matrix switch **19***b* embodied as illustrated in FIG. 5B. In this embodiment consecutive rows **45***b* of the apertures **41***b* are designated by reference numerals **51, 53, 55,** and **57.** Also, it will be noted that particular ones of the second conductors **23***b*, such as the particular conductors **59** and **61**, can extend through a switch **20***b* in each of an alternate pair of rows **51, 53, 55,** and **57.** For example, the particular conductor **59** extends through a switch **20***b* in each of the rows **53** and **57** and the particular conductor **61** extends through a switch **20***b* in each of the rows **51** and **55.** Each of the particular second conductors **23***b* extending through a pair of switches **20***b* is preferably bisected between the associated pair of the switches **20***b*. Thus, the bisected second conductors **23***b* provide a plurality of third conductors **63** terminating on the second side **50***b* of the second backing member **29***b* and a plurality of fourth conductors **67***b* terminating on the first side **48***b* of the second backing member **29***b*. The bisecting of the second conductors **23***b* can be accomplished by punching a plurality of holes, such as the holes **71**, through the laminate so as to sever the particular second conductors **23***b* between the associated pair of the switches **20***b*. In the preferred embodiment, each of the holes **71** is defined in part by discrete portions of one of the particular second conductors **23***b* at a location between the adjacent rows **53** and **55** of the switches **20***b*.

Also in this embodiment, it is particularly desirable that both the first and second edges **48***b* and **50***b* of the second backing member **29***b* extend beyond the first backing member **27***b* and the dielectric spacer **39***b* so that the third conductors **63** are exposed on the second edge **50***b* and the fourth conductors **67** are exposed on the first edge **48***b*. This embodiment of the matrix switch **19***b* is particularly advantageous since a discrete switch is provided for each of the keys on the keyboard but the number of second conductors **23***b* is substantially one half the number illustrated in the matrix switch **19***a* shown in FIG. 5A.

The concepts of this invention can be embodied to accommodate keyboards wherein the keys are disposed in rows and columns which are substantially perpendicular to the rows. Furthermore, the spacing of the columns may not be symmetrical. These characteristics are typified by a common adding machine keyboard of the type shown generally at **13***c* in FIG. **6.** The keys **15***c* of the keyboard **13***c* are arranged in a first group **64** of numerical keys disposed between a second and third group **66** and **68,** respectively, of function keys. The rows **45***c* of the keys **15***c* include consecutively adjacent rows **69, 71, 73,** and **75** which are common to each of the groups **63, 65,** and **67.** Similarly, the columns **47***c* of the keys **15***c* include the columns **77** and **79** in the first group **64** and the column **81** in the third group **68.** The columns **47***c* can have a first angular relationship, such as a perpendicular relationship, with the rows **45***c*.

On the keyboard **13***c* the spacing between adjacent columns within each of the groups, such as the columns **77** and **79** in group **64,** can be less than the spacing between adjacent columns in adjacent groups, such as the columns **79** and **81** in the first and third groups **64** and **68,** respectively. For example, in a preferred embodiment the columns **77** and **79** are spaced 0.750 inches while the columns **79** and **81** are spaced 1.125 inches.

A matrix switch **19***c* embodied as illustrated in FIG. **6A** can include switches **20***c* spaced in accordance with the spacing of the keys **15***c* of the keyboard **13***c* (FIG. **6**). In this embodiment the first conductors **21***c* extend in a first direction corresponding to the rows **69, 71, 73,** and **75** of the keys **15***c*. The second conductors **23***c* preferably extend in a second direction having an angular relationship with both the columns **47***c* of the key **15***c* and the first conductors **21***c*. For example, the second conductors **23***c* can be disposed at an angle 26° 34′ to the direction of columns **47***c*. At this angle some of the second conductors **23***a* such as the conductors **83** and **85** will extend between a switch **20***c* in each of an

alternate pair of the rows **45***c*. For example, the conductor **83** extends through a switch **20***c* in each of the rows **69** and **73** and the conductor **85** extends through a switch in each of the rows **71** and **75.** The second conductors **23***c* extending through a pair of the switches are preferably bisected between the pair of switches to provide a terminal for each of the switches on one of the edges **48***c* and **50***c* of the backing member **29.**

Due to the increased spacing between the columns **47***c* in adjacent groups, some of the second conductors **23***c*, such as the particular conductor **87,** may extend through only one of the switches **20***c*, such as the associated switch **88.** The particular second conductor **87** need not be bisected in which case the associated switch **88** is terminated on both of the edges **48***c* and **50***c* of the second backing member **29***c*.

The increased spacing between the columns **47***c* in adjacent groups can also provide second conductors **23***c* which extend through a pair of switches **20***c* disposed in non-alternate rows. Thus, the particular second conductor **82** extends through the switches **84** and **86** in the rows **69** and **75.** The particular second conductor **82** is preferably bisected so that the switches **84** and **86** are individually terminated on one of the edges **48***c* and **50***c*.

The concept of the switching matrix can be embodied to accommodate a keyboard having a plurality of keys aligned in rows and columns which are evenly spaced. Such a matrix might include the switches **20***d* which are illustrated in FIG. 7 to be symmetrically spaced to correspond to the spacing of the keys. In FIG. 7, 20 of the switches **20***d* are consecutively lettered from A to T and disposed in four rows and five columns. The switching matrix **19***d* is merely representative of that which can be used with any symmetrical keyboard having any number of keys. Furthermore, although the switches A to T have a symmetrical spacing of 0.75 inches in the preferred embodiment, the concept of the invention can be applied to any spacing of the keys and switches.

As illustrated in FIG. 7, the switches A to T are arranged in rows **83** and columns **85** and the columns **85** have an angular relationship such as a perpendicular relationship to the rows **83.** The first conductors **21***d* can extend individually through the rows **83,** and the second conductors **23***d* can be disposed in an angular relationship with both the rows **83** and columns **85.** The second conductors **23***d* can include a series of conductors, such as the series of conductors **87** and **89,** for each of the columns **85** of the switches A to T. The number of conductors in each of the series of conductors **87** and **89** can be equal to the number of rows **83** of the switches **20***d*. This will enable conductors in each of the series of conductors **87** and **89** to extend through one of the switches **20***d* in the associated column **85** of switches **20***d*. This configuration can provide a terminal for each of the switches A to T in accordance with the corresponding letters on the first edge **48***d*.

In the preferred embodiment, the switches **20***d* are disposed on 0.75 inch centers and the second conductors **23***d* have a maximum width of 0.125 inches. With these dimensions, the matrix switch **19***d* could be expanded to include six switches **20***d* in each of six rows **45***d*.

If the columns **85** are more closely spaced, it may be advantageous that some of the second conductors **23** extend through more than one of the switches **20.** Under such circumstances, the matrix switch **19***e* shown in FIG. 7A may be particularly desirable. In this embodiment, some of the second conductors **23***e* may be shared between adjacent series of conductors, such as the series **87***e* and **89***e*. For example, the particular conductors **91** and **93** are included in both the series of conductors **87***e* and **89***e*. These particular conductors **91** and **93** extend through a switch in each of an adjacent pair of the columns **85***e* so that it is desirable to bisect the particular conductors **91** and **93** between the associated switches. Thus, the particular conductor **91** is bisected between the switches B and K and the particular conductor **93** is bisected between the switches G and P. This will provide each of the associated switches with a discrete terminal. Thus, in the switching matrix **19***e*, the second conductors **23***e* of each of the switches A to T are terminated in accordance with the respective letters on the edges **48***e* and **50***e* of the second backing member **29***e*. It will also be noted that the common line **49***e* is shown to be welded to each of the first conductors **21***e* through a plurality of apertures **38** in the spacing member **39***e*.

Since a single second conductor **23***e* can accommodate more than one switch, the ultimate size of the matrix is significantly increased. For example, if the switches **20***e* are on 0.75 inch centers and the second conductors **23***e* have a maximum width of 0.125 inches, the matrix switch **19***e* can be expanded to accommodate **12** switches **20***e* in each of **12** rows. Even larger matrices can be made if the spacing of the switches **20***e* is increased or the width of the second conductors **23***e* is decreased.

A keyboard having symmetrically spaced keys can be provided with a switching matrix of still another embodiment wherein the angular relationship of the rows **45** and columns **47** is the same as the angular relationship of the first conductors **21** and the second conductors **23.** Thus, the matrix switch can be embodied, as in FIG. 7B, to accommodate switches symmetrically spaced in rows **45***f*, including an adjacent pair of particular rows **95** and **97.** Particular ones of the first conductors **21***f* can individually extend through the switches **20***f* in each of the rows **45***f*. For example, a particular conductor **99** can extend through the switches **20***f* in the row **95** and a particular conductor **101** can extend through the switches **20***f* in the row **97.** Additionally, an intermediate first conductor **21***f* can extend between each of first conductors **21***f* which pass through the switches **20***f* in an adjacent pair of the rows **45***f*. For example, the intermediate conductor **103** can extend between the particular conductors **99** and **101.**

Similarly, the second conductors **23***f* can include a particular conductor **105** and a particular conductor **107** each extending through an adjacent pair of the columns **47***f*. The second conductors **23***f* can also include an intermediate second conductor **109** extending between the particular conductors **105** and **107.**

In addition to the apertures **41***f*, the dielectric spacing member **39** can include a plurality of apertures **111** which are disposed at the points of intersection between the particular first conductor **103** and each of the second conductors **23***f*. The conductor **103** and each of the second conductors **23***f* can be electrically connected by welding or soldering through each of the apertures **111.** Each of the particular second conductors passing through the switches **20***f*, such as the conductors **105** and **107**, are preferably bisected between

the particular first conductors **99** and **103.** This can be accomplished by punching a hole, such as the hole **113,** through the laminate in a manner similar to the punching of the holes **71***f* so that the conductors **105** and **107** are severed. The intermediate first conductors **103** is also preferably bisected between the particular second conductors **105** and **107** and on one side of the intermediate second conductor **109.** This bisecting can be accomplished by punching a hole, such as the hole **115,** through the laminate so that the intermediate first conductor **103** is severed at the location of the hole **115.**

In this manner, the switches disposed on the particular rows **95** and **97** can be provided with discrete terminals on one of the edges **48***f* and **50***f* as illustrated by the respective letters A to T. An additional pair of the rows **45***f* of switches **20***f* can be accommodated by the second conductors **23***f* so that the switches **20***f* associated therewith are terminated on the opposite edge **50***f* of the second backing member **29.** As previously noted, it is desirable in such an embodiment to bisect the second conductors typically by punching the holes **71***f* through the laminate between the associated pairs of the rows **45***f.*

The matrix switch **19** of the present invention can be embodied as illustrated in FIG. **12** to terminate on a standard collated cable adapter board **165** which has a plurality of conductors **167** printed thereon. In this particular embodiment, the first conductors **21***g* are arranged in pairs, and each of the pairs is associated with one of the switches **20***g*. For example, a particular pair of the conductors **21***g* include a conductor **171** and a conductor **173,** both of which are associated with the key having the indicia **7.** As in some of the previous embodiments, each of the second conductors **23***g* is associated with a particular row of the switches **20***g*.

The dielectric spacing member **39***g* separates the first and second conductors **21***g* and **23***g*, respectively, except in the general areas of their intersection. In each of these areas, one of the keys **15** (FIG. **4**) is disposed to press the associated pair of the first conductors **21***g* into electrical contact with the associated second conductor **23***g*. Thus, by pressing an individual key **15,** the signal present on one of the conductors in the associated pair of first conductors **21***g* passes through the associated second conductor **23***g* to the other of the conductors in the particular pair of first conductors **21**g. For example, by pressing the key associated with the indicia **7,** the signal present on the conductor **171** is shorted across the associated second conductor **23***g* to the conductor **173.** It is apparent that in this particular embodiment the second conductors **23***g* function primarily to short the conductors **21***g* in a particular pair of the conductors **21***g*. Also, it will be noted that generally speaking, the first conductors **21***g* are not directly and permanently connected to the electronics associated with the particular operation.

A collated cable **175** can be disposed with its substantially parallel conductors **177** extending transverse to the first conductors **21***g* and respectively terminating on the conductors **167.** Generally, the switches **20***g* can be connected to the conductors **177** in accordance with random groupings of the switches **20***g*. For example, the switches **20***g* can be formed into a plurality of first groups including all of the switches **20***g* and a plurality of second groups including all of the switches **20***g*. Each of the switches **20***g* is included in one of the first groups and one of the second groups, so that the number of switches **20***g* can be no greater than the product obtained by multiplying the number of first groups by the number of second groups. The conductors **177** can be designated to correspond respectively to one of the first or second groups of switches **20***g*. Then, each of the pairs of first conductors **21***g* can be electrically connected to those conductors **177** which have the particular first and second group designations corresponding to the associated switch.

Referring to FIG. **12,** it will be noted that the conductors **177** include particular conductors **179** and **181** which correspond to two random groups of switches **20***g* among the function switches shown generally at **183.** Also, the particular conductors **187, 189,** and **191** correspond to the three random groups of switches **20***g* among the numbered switches shown generally at **185.** The particular conductor **191** also corresponds to the group of switches to the right of the numbered switches **185.** The pairs of conductors **21***g* for each of the switches **20***g* can be connected as previously described. This is merely one example of how the switches **20***g* can be formed into first groups to facilitate repairs, wherein a particular failure can be localized to the function switches or the number switches.

Of course, the first and second groups of switches **20***g* can correspond respectively to the rows and columns of the switches **20***g*. Then, each of the pairs of first conductors **21***g* can be electrically connected to those conductors **177** which have the particular row and column designations corresponding to the associated switch.

This particular matrix switch can be formed as a laminate as shown in FIG. **14.** The first backing member **27***g* and the dielectric spacing member **39***g* can extend substantially across the entire matrix switch **19***g* with the first conductor **21***g* sandwiched therebetween.

A separate collated cable including the backing member **29***g* and the shorting second conductors **23***g* can be disposed on the side of the spacing member **39***g* opposite the first conductors **21***g* to form the switches **20***g*. A further collated cable **175** including the conductors **177** can be simultaneously located on the side of the spacing member **39***g* opposite the first conductors **21***g*, typically in spaced relationship to the switches **20***g*.

In addition to the apertures **41***g* which can be formed between the first and second conductors **21***g* and **23***g*, respectively, the spacing member **39***g* can also be provided with an aperture **193** at each of the points of intersection where one of the first conductors **21***g* is to be connected to one of the conductors **177.** In such an embodiment, the associated conductors **21***g* and **177** are connected through the associated apertures **193.** Alternatively, at each of these points of intersection, the associated conductors **23***g* and **177** can be soldered, resistance-welded, ultransonically welded, or otherwise connected by melting the backing member **29***g* and the dielectric spacer **39***g* at each of the points of connection. Such a weld is shown generally at **195** in FIG. **13.** Although the conductors **23***g* and the conductors **177** are illustrated to be included in separate collated cables, it will be apparent that these conductors can be collated on a single backing member.

As illustrated in FIG. **14,** a matrix switch **19** similar to that shown in FIG. **12** can be provided to accommodate a standard typewriter keyboard. In such an embodiment, the first and second conductors **21***h* and **23***h*

may be oriented in substantially perpendicular directions. It is of interest to note that the pairs of first conductors **21***h* include a first and second particular pair of conductors which are designated generally by the reference numerals **197** and **199**, respectively. The second conductors **23***h* also include a particular pair of conductors which is designated by the reference numeral **201**. These conductors are of particular interest since the particular first conductors **197** pass through the switches associated with both the letter B and the "space." Thus, the particular conductors **197** violate the general rule that a single pair of the second conductors **23***h* should be associated with only a single switch **20***h*.

In such a case, the particular conductors **197** can be cut or otherwise provided with a discontinuity between the associated pair of switches designated B and "space." Then the particular conductors **197** can be soldered or otherwise connected to the particular conductors **201** as illustrated generally at **203**. Similarly, the particular conductors **201** can be connected to the conductors **199** as illustrated generally at **205**. The conductors **199** can be connected to the conductors **177***h* of the collated cable **175***h* in the manner previously discussed.

Referring again to FIG. **1**, it will be noted that the matrix switch **19** can register with the bar clamp **25** to provide an interface between the switch **20** and the associated electronics (not shown) of the controlled operation. Referring now to FIG. **9**, it will be noted that the bar clamp **25** can include first retaining means **125** which cooperates with a clamp plate **127** to receive the ends of the second conductors **23**. In such an embodiment, the second conductors **23** can face the first retaining member **125** so that the outer surface **37** of the backing member **29** contacts the clamp plate **127**. The first retaining member **125** preferably includes portions **130** which define a plurality of first slots **131** each aligned with and receiving one of the second conductors **23**. The matrix switch **19** may be maintained in a substantially fixed relationship with the bar clamp **25** by the frictional engagement of the portions **130** and the conductors **23**, and the frictional engagement of the clamp plate **127** with the backing member **29**.

A plurality of conductors **133** preferably extend from an outer surface of the first retaining member **125** to contact respectively the second conductors **23**. The conductors **133** are preferably formed from discrete strips of material each having a relatively high electrical conductivity.

Each of the conductors **133** can be constructed to exert a force upon the associated second conductors **23** to enhance the electrical contact therebetween. For example, the conductors **133** can include first portions **135** having a substantially fixed relationship with the first retaining member **125**, and the portions **137** slidingly engaging the first retaining member **125** interiorly of the slots **131**. Third portions **139** of the conductors **133** can extend between the first and second portions **135** and **137**, respectively, to contact the associated second conductors **23**. If the third portions **139** are normally biased to extend from the slots **131**, then they will exert a pressure upon the second conductors **23** when the portions **130** contact the second conductors **23**.

It will be apparent to those skilled in the art that the first retaining member **125** can be molded from an insulating material with the portions **135** of the conductors **133** embedded in the first retaining member **125**. It may be desirable, however, that the conductors **133** more loosely engage the first retaining member **125** to facilitate replacement of the conductors **133**. In such an embodiment, the first retaining member **125** can be constructed to define a plurality of slots **141**. The slots **141** preferably extend from each of the slots **131**, along the surface of the member **125** facing toward the switches **20**, and terminate at the surface of the member **125** facing away from the switches **20**.

A second retaining member **143** can be disposed to engage the first retaining member **125** to form a channel **145** with each of the slots **141**. The conductors **133**, which preferably extend through the channels **145** are loosely held in a substantially fixed relationship between the first and second retaining members **125** and **143**, respectively. Portions **146** of the conductors **133** extending from the channels **145** can be configured to facilitate their connection to conductors **148** of the associated electronics. In this manner, the bar clamp **25** interfaces the matrix switch **19** with the associated electronics by providing electrical continuity between the conductors **23** and the conductors **148**.

It will be apparent to those skilled in the art that the bar clamp **25** is particularly adapted for use with a clamp plate **127**, such as a board having a circuit **129** printed on the surface thereof. As illustrated in FIGS. **10** and **11**, the first retaining member **125** preferably contacts the outer surface **37** of the backing member **29** so that the second conductors **23** are forced into electrical contact with the circuit **129**. In such an embodiment, the conductors **133** may not carry any signal, in which case their primary function is to exert pressure upon the backing member **29** to facilitate the electrical contact between conductors **23** and the circuit **129**. It will be appreciated by those skilled in the art that this function can be performed by any biasing means preferably extending between the first retaining member **125** and the backing member **29**.

The first and second retaining members **125** and **143**, respectively, and the conductors **133** can be constructed in a subassembly. In such a subassembly, the first and second retaining members **125** and **143**, respectively, may define at least a pair of apertures **147** extending substantially perpendicularly to the clamp plate **127**. A tubular member **149** for each of the apertures **147** can be provided with a flanged end **153** and a flangable end **151**. After the conductors **133** have been disposed in the slots **141**, the second retaining member **143** can be brought into cotiguous relationship with the first retaining member **125** so that the apertures **147** in the first and second retaining members **125** and **143**, respectively, are aligned. In this position, the second member **143** caps the slots **141** to partially define the channels **145**. With each of the apertures **147** aligned, the flangable end **151** of each of the tubular members **149** can be passed through the respective apertures **147** until the flanged end **153** contacts the second retaining member **143**. Then the flangable end **151** can be flanged to contact the first retaining member **125** and thereby complete the subassembly.

The clamp plate **127** can be constructed to define a hole **155** having a coaxial relationship with each of the apertures **147**. A threaded member, such as the bolt **157**, can be passed through each of the tubular members **149** and the associated holes **155** until the head of the bolt **157** engages the flanged end **153**. A nut **159**

can be screwed on the threads of the bolt **157** to engage the clamp plate **127.** In this manner, the subassembly including the conductors **133** can be held in fixed relationship with the clamp plate **127,** with the backing member **29** and the conductors **23** sandwiched therebetween. It may also be desirable that the backing member **29** be provided with a hole **161** preferably aligned with each of the apertures **147** to receive the bolts **157.** This embodiment will enable the matrix switch **19** to be bolted to the bar clamp **25** and the clamp plate **127.**

The switching matrix **19** of the present invention provides a significant advance over the prior art. Major steps in the formation of each of the embodiments illustrated and described can be accomplished in accordance with the high-speed methods associated with collated cable, so that the switching matrix **19** can be constructed at a significantly low cost per switch.

Although the switching matrix **19** can be formed with the planar spacing member **39,** particular embodiments may be more advantageously constructed with the longitudinal spacing members **39'.** The longitudinal spacing members **39'** can be collated on the backing member **27** simultaneously with the disposition of the first conductors **21** thereon. This not only eliminates a separate part, but also significantly reduces problems associated with alignment and quality control. The matrix switch **19** can be adapted to operate in conjunction with many of the standard keyboards associated with typewriters, adding machines, and computers, etc.

The matrix switch **19** can be terminated by the bar clamp **25** not only to hold the switching matrix **19** in a fixed position with respect to the keyboard **13,** but also to provide the automatically biased conductors **133** which receive the signals from the second conductors **23** and provide an interface with the associated electronics. Alternatively, the bar clamp **25** can be used in conjunction with a board **127** having a circuit **129** printed thereon in which case the biased conductors **133** force the second conductors **23** into electrical contact with the circuit **129** on the board **127.**

Although this application has been disclosed and illustrated with reference to particular applications, the principles involved are susceptible of numerous other applications which will be apparent to persons skilled in the art. The invention is, therefore, to be limited only as indicated by the scope of the appended claims.

I claim:

1. A switch assembly having a plurality of switches for switching an input signal and being adapted for use with a keyboard having a plurality of keys each associated with one of the switches, the keys being aligned in a plurality of rows each extending in a first direction and a plurality of columns each extending in a second direction transverse to the first direction, the assembly comprising:

a first backing member having a substantially planar inner surface and electrical insulating properties;

a plurality of first conductors disposed on the inner surface of the first backing member and each having the input signal thereon, the first conductors extending in the first direction and spaced in electrically insulated relationship to one another;

a second backing member having a substantially planar inner surface and electrical insulating properties;

a plurality of second conductors disposed on the inner surface of the second backing member and extending in a third direction different from the first direction and the second direction and spaced in electrically insulated relationship to one another, at least one particular conductor included among the second conductors on the second backing member and extending in close proximity to an associated pair of the first conductors on the first backing member at a particular pair of the switches;

portions of at least the second backing member defining an aperture which extends across and interrupts each of the particular conductors to break the electrical continuity of the associated particular conductor between the associated particular pair of the switches;

insulation means disposed in juxtaposition to the inner surface of the first backing member and the inner surface of the second backing member for normally insulating the first conductors from the second conductors, the insulating means defining a plurality of openings between the associated first conductor and the associated second conductor at each of the switches; whereby

the keys of the keyboard are actuable to move the associated second conductor through the associated opening in the insulation means and into electrical contact with the associated first conductor to switch the input signal from the associated first conductor to the associated second conductor.

2. The switch assembly recited in claim **1** further comprising:

means for introducing the input signal to one of the first conductors; and

one of the second conductors being electrically connected to each of the first conductors so that the input signal introduced to the one first conductor is introduced to all of the first conductors.

3. The switch assembly recited in claim **1** wherein the second direction is substantially perpendicular to the first direction.

4. The switch assembly recited in claim **3** wherein the third direction is substantially perpendicular to the first direction.

5. A combination for providing a plurality of switches disposed in at least first, second, third and fourth consecutively adjacent rows and a plurality of columns, the switches having properties for being selectively actuated to control an operation, the combination including:

a plurality of first conductors disposed to extend in a first direction in electrically insulated relationship to one another and including among the plurality of first conductors a particular first conductor;

a plurality of second conductors disposed to extend in a second direction different than the first direction in electrically insulated relationship to one another and including among the plurality of scond conductors a particular second conductor;

a spacing member having properties for electrically insulating the first conductors from the second conductors and including particular portions thereof defining an opening between the particular first conductor and the particular second conductors;

at least one actuating means defining with the particular first and second conductors a particular one of the switches, the actuating means having properties for being moved to force one of the particular first and second conductors through the opening in the spacing member and into contact with the other of the particular first and second conductors;

a plurality of third conductors included among the second conductors;

a plurality of fourth conductors included among the second conductor and alternating with the third conductors;

at least a particular one of the third conductors extending through a switch in the first row of the switches and a switch in the third row of the switches;

at least a particular one of the fourth conductors extending through a switch in the second row of the switches and a switch in the fourth row of the switches; wherein

the particular third conductors are bisected between the associated switch in the first row and the associatd switch in the third row, and the particular fourth conductors are bisected between the associated switch in the second row and the associated switch in the fourth row.

6. The combination as set forth in claim **5** wherein the particular third and fourth conductors are bisected between the second and third rows of switches.

7. A combination for providing a plurality of switches disposed in rows and columns, the switches having properties for being selectively actuated to control an operation, the combination comprising:

a plurality of first conductors having a electrically insulated relationship to one another and disposed to extend in a first direction through the switches in an associated row of the switches;

a plurality of second conductors havig an electrically insulated relationship to one another and disposed to extend in a second direction different than the first direction to define points of substantial intersection between the first conductors and the second conductors, at least one of the second conductors extending through an associcated pair of the switches in different rows of the switches and the one second conductor being interrupted between the associated pair of the switches to electrically insulate the associated pair of the switches;

a spacing member having properties for normally electrically insulating the first conductors from the second conductors, the spacing member including particular portions which define an opening at each of the points of substantial intersection between the first and second conductors; and

actuating means selectively movable to force one of an associated pair of the first and second conductors through the associated opening in the spacing member and into contact with the other of the associated pair of first and second conductors to provide an electrical interconnection between the associated pair of first and second conductors.

8. The combination recited in claim **7** wherein an input signal is introduced to a particular one of the first conductors and a particular one of the second conductors is connected to each of the first conductors to provide electrical continuity between the first conductors whereby the input signal introduced to the particular first conductor is introduced to all of the first conductors.

9. The combination as recited in claim **7** wherein the switch columns have a transverse relationship with respect to the second direction and the first direction.

10. The combination as defined in claim **9** wherein the switch columns have a transverse relationship with respect to the switch rows and the first direction is substantially perpendicular to the second direction.

11. The combination as recited in claim **9** wherein the switch columns are substantially perpendicular to the switch rows and the first direction has a transverse relationship with respect to the second direction.

12. A combination for providing a plurality of switches disposed in rows and columns, the switches being responsive to an input signal and having properties for being selectively actuated to control an operation, the combination comprising:

a plurality of first conductors having an electrically insulated relationship to one another and disposed to extend in a first direction through the switches in an associated row of the switches, the input signal being introduced to a particular one of the first conductors;

a plurality of second conductors having an electrically insulated relationship to one another and disposed to extend in a second direction different than the first direction to define points of substantial intersection between the first conductors and the second conductors, a particular one of the second conductors being connected to each of the first conductors to provide electrical continuity among the first conductors whereby the input signal introduced to the particular first conductor is introduced to all of the first conductors;

a spacing member having properties for normally electrically insulating the first conductors from the second conductors, the spacing member including particular portions which define an opening at each of the points of substantial intersection between the first and second coductors; and

a plurality of actuating means selectively movable to force one of an associated pair of first and second conductors through the associated opening in the spacing member and into contact with the other of the associated pair of first and second conductors to provide an electrical interconnection between the associated pair of first and second conductors.

13. The combination as defined in claim **12** wherein each of the first conductors is associated with more than one of the plurality of switches and at least one of the second conductors is associated with only one of the plurality of switches.

14. The combination as recited in claim **12** wherein at least one of the first conducotrs is associated with a plurality of the switches and particular ones of the second conductors are associated with a pair of the switches, the particular second conductors being electrically separated between the pair of switches so that a different portion of each of the particular second conductors extends through one of the switches in the pair of switches.

15. The combination as recited in claim **12** wherein the actuating means further comprises:

a keyboard having a plurality of keys each positioned with respect to an associated one of the plurality of switches for individually actuating the associated

switches, each of the keys having characteristics for movement at the points of substantial intersection between individual ones of the first and second conductors to move the associated first conductors relative to and into electrical contact with the associated second conductor at the associated point of substantial intersection.

16. A combination for providing a plurality of switches disposed in rows and columns, the switches having properties for being selectively actuated to control an operation, the combination comprising:

a plurality of first conductors having an electrically insulated relationship to one another and disposed to extend in a first direction through an associated row of the switches;

a plurality of second conductors having an electrically insulated relationship to one another and disposed to extend in a second direction different than the first direction, to define points of substantial intersection between the first conductors and the second conductors;

a spacing member having properties for normally electrically insulating the first conductors from the second conductors, the spacing member including particular portions which define an opening at each of the points of substantial intersection between the first and second conductors;

a plurality of actuating means selectively movable to force one of an associated pair of the first and second conductors through the associated opening in a spacing member and into contact with the other of the associated pair of first and second conductors to provide electrical connection between the associated pair of first and second conductors; and

at least one series of the second conductors being associated with a column of the switches and adjacent second conductors in each of the series of second conductors being associated with adjacent switches in the associated columns of the switches.

17. The combination as defined in claim **16** wherein:

the series of second conductors include a first series of second conductors associated with a first column of the switches and a second series of the second conductors associated with a second column of the switches adjacent to the first column of the switches;

a particular one of the second conductors is shared by the first series of the second conductors and the second series of the second conductors so that the particular conductor is associated with a particular pair of the switches in adjacent columns of the switches; and

the particular second conductor is bisected between the particular pair of the switches.

18. The combination as defined in claim **16** wherein the conductors in each of the series of conductors are different from the conductors in the other series of conductors.

19. A switching matrix for selectively switching an input signal to control an operation, comprising:

a plurality of first conductors disposed in spaced relationship to one another and extending in a first direction;

a plurality of second conductors disposed in spaced relationship to one another and extending a second direction different than the first direction;

a plurality of points of substantial intersection each defined by one of the first conductors substantially crossing one of the second conductors;

a spacing member disposed between the first and second surfaces except in proximity to each of the points of substantial intersection of the first conductors and the second conductors;

a plurality of switches each defined by an associated one of the first conductors and associated one of the second conductors, the switches being operable by relatively pressing the associated second conductor into contact with the associated first conductor at the associated point of substantial intersection to switch the input signal from the associated first conductor to the associated second conductor;

the switches being aligned in a plurality of switch rows including a first switch row and a second switch row;

a third conductor included among the first conductors and being associated with the switches in the first switch row;

a fourth conductor included among the first conductors and being associated with the switches in the second switch row;

a fifth conductor included among the second conductors and being associated with a first switch in the first switch row and a second switch in the second switch row;

a sixth conductor included among the second conductors and being disposed adjacent to the fifth conductor;

a seventh conductor included among the first conductors and being electrically connected to the fifth conductor and the sixth conductor between the third conductor and the fourth conductor;

a fifth conductor being interrrupted between the seventh conductor and the fouth conductor; whereby the input signal on the first conductor is switched to the sixth conductor by operation of the first switch and the input signal on the fourth conductor is switched to the fifth conductor by operation of the second switch.

20. A matrix of switches including:

a plurality of pairs of first conductors extending in a first direction and having an input signal impressed on one of the conductors in each of the pairs of first conductors;

a plurality of second conductors extending in a second direction transverse to the first direction and defining one of the switches with each of the pairs of first conductors, the second conductors being movable relative to an associated pair of the first conductors to short circuit the associated pair of first conductors and thereby switch the input signal on the one conductor of the associated pair of first conductors to the other conductor of the associated pair of first conductors;

the switches being combined into a plurality of first groups of the switches and a plurality of second groups of the switches;

a plurality of third conductors extending transversely to the first direction and spaced in an electrically insulated relationship to each other, each of the third conductors being connected to one of the pair of first conductors associated with a different one

of the switches in one of the first groups of switches; and

a plurality of fourth conductors extending transversely to the first direction and spaced in electrically insulated relationship to each other, each of the fourth conductors being electrically connected to a different one of the pair of conductors associated with the switches in one of the second groups of switches; whereby

the short circuiting of a particular pair of the first conductors provides electrical continuity between a particular one of the third conductors and a particular one of the fourth conductors.

21. The matrix of switches recited in claim **20** wherein the switches are arranged in rows and columns and the first groups of swiches correspond to the rows of the switches and the second groups of switches correspond to the columns of the switches.

22. A matrix of switches responsive to an input signal and adapted for use with a keyboard having a plurality of keys aligned in rows and columns and individually actuable to control an opperation, comprising:

a first backing member having a generally planar configuration;

a plurality of nonintersecting first conductors disposed on the first backing member and adapted to receive the input signal;

a second backing member having a generally planar configuration;

a plurality of nonintersecting second conductors disposed on the second backing member;

a spacing member having a generally planar configuration and dielectric characteristics, the spacing member being disposed in juxtaposition to the first conductors on the first backing member and the second conductors on the second backing member to normally electrically insulate the first conductors from the second conductors;

the second conductors extending in generally trasnverse, nonperpendicular relationship to the first conductors to substantially intersect the first conductors at a plurality of points each defining the location of one of the switches of the matrix and each of the switches being associated with one of the keys of the keyboard;

portions of the spacing member defining a hole between an associated one of the first conductors and an associated one of the second conductors at each of the points of substantial intersection to permit operation of the associated key of the keyboard to press one of the associated first and second conductors through the associated hole in the spacing member into electrical contact with the other of the associated first and second conductors; whereby

the input signal on the associated first conductor is switched to the associated second conductor to control the operation.

23. The matrix of switches recited in claim **22** wherein the rows of the switches are substantially perpendicular to the columns of the switches and each of the second conductors is associated with an individual one of the switches in the matrix of switches.

24. The matrix of switches recited in claim **22** wherein at least a particular one of the second conductors is associated with a particular pair of switches in different rows of the switches and the particular second conductor is interrupted between the particular switches to provide the particular switches with independent switching characteristics.

25. The matrix of switches recited in claim **22** whrein a particular one of the first conductors is adapted to receive the input signal and a particular one of the second conductors is conneted to each of the first conductors so that the input signal on the particular first conductor is introduced to all of the other first conductors.

26. A matrix of switches including:

a plurality of pairs of first conductors extending in a first direction and having an input signal impressed on one of the conductors in each of the pairs of first conductors;

a plurality of second conductors extending in a second direction transverse to the first direction to define an area of close proximity with each of the pairs of first conductors and to define one of the switches at each of the areas of close proximity;

a spacing member disposed between the first conductors and the second conductors, portions of the spacing member defining an opening at each of the areas of close proximity;

the second conductors being movable relative to an associated pair of first conductors and through the associated opening in the spacing member to short circuit the associated pair of the first conductors; whereby

the input signal on the one conductor of the associated pair of first conductors is switched to the other conductor of the associated pair of first conductors.

27. The matrix of switches recited in claim **26** wherein each of the pairs of the first conductors defines at leastone of the switches at the areas of close proximity with a respective one of the second conductors so that the switches are aligned in rows extending in the second direction and columns extending in the first direction.

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