United States Patent [19]

Townsend

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[45] **Sept. 25, 1973**

[54] **LATCHING SWITCH**

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

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[52] **U.S. Cl.** **337/78,** 337/359, 337/365, 337/370

[51] **Int. Cl.** **H01h 61/00**

[58] **Field of Search** 337/55, 75, 76, 77, 337/78, 102, 104, 105, 95, 356, 357, 358, 359, 362, 365, 370

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[57] **ABSTRACT**

A latching switch comprising two normally electrically isolated contact elements which mechanically latch to complete an electrical connection when deflected in a prearranged sequence in substantially orthogonal directions. Each element of the switch is comprised of a bimetal, deflection thereof being effected electrothermally.

9 Claims, 7 Drawing Figures

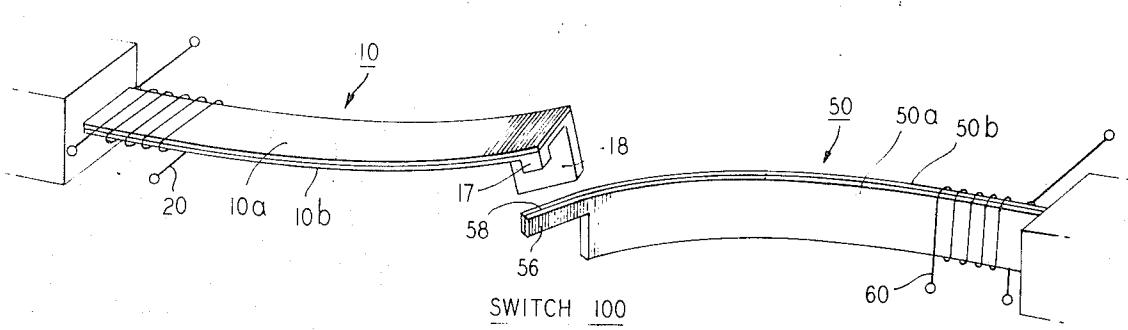


FIG. 1

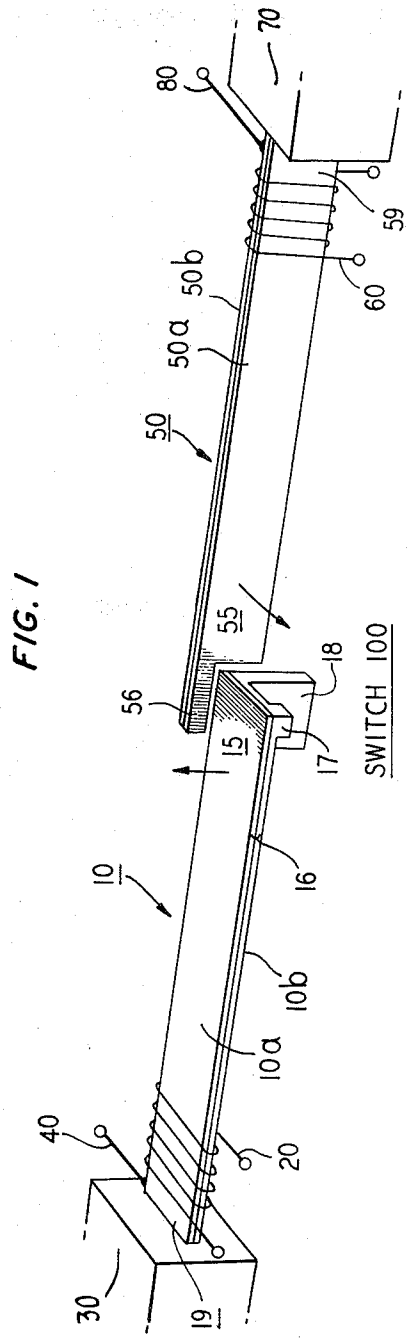

70
80
59
60
50b
50a
50
55
18
56
15
17
SWITCH 100
10
16
10b
10a
40
20
30
19

FIG. 2

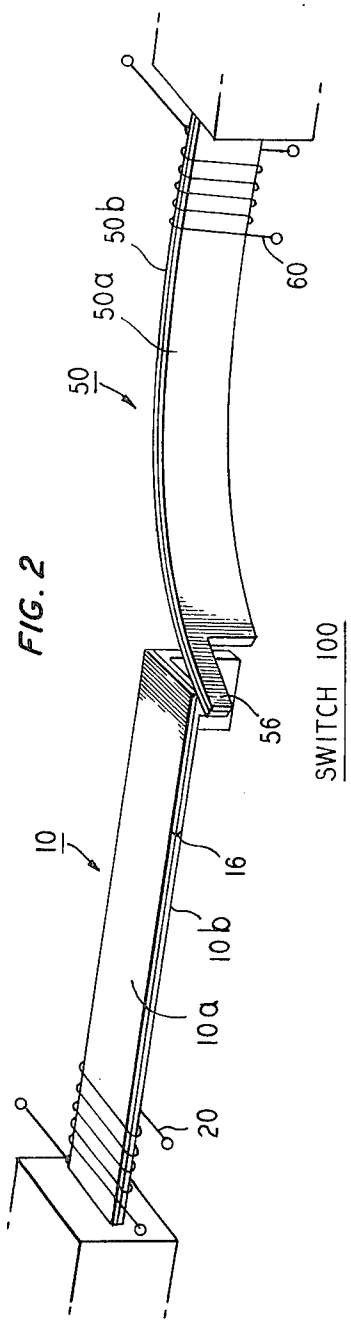

50b
60
50a
50
56
SWITCH 100
10
16
10b
10a
20

FIG. 3

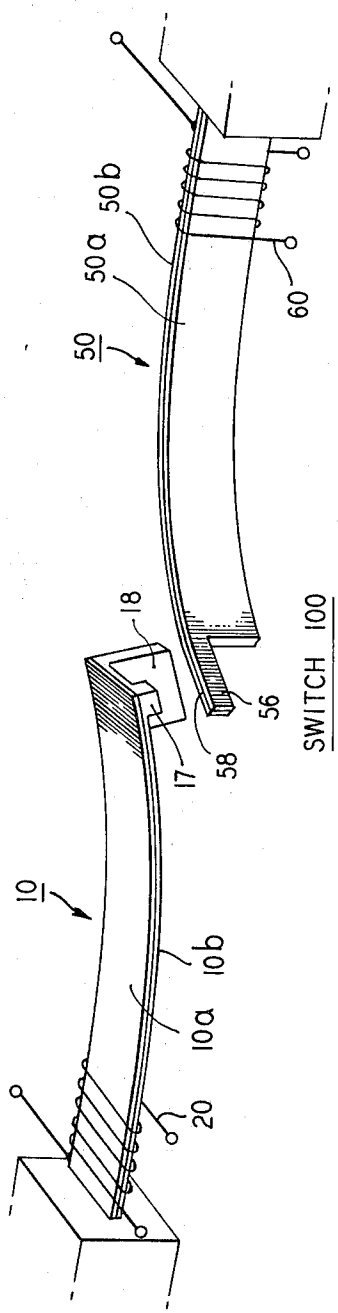

50b
50a
50
60
18
56
58
17
SWITCH 100
10
10b
10a
20

FIG. 4

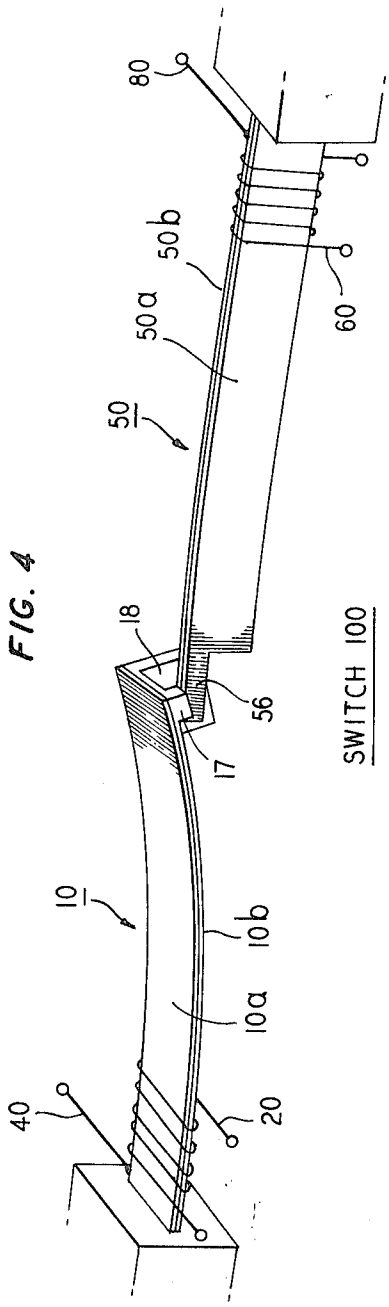

80
50b
50a
50
60
18
56
17
SWITCH 100
10
10b
10a
40
20

FIG. 5

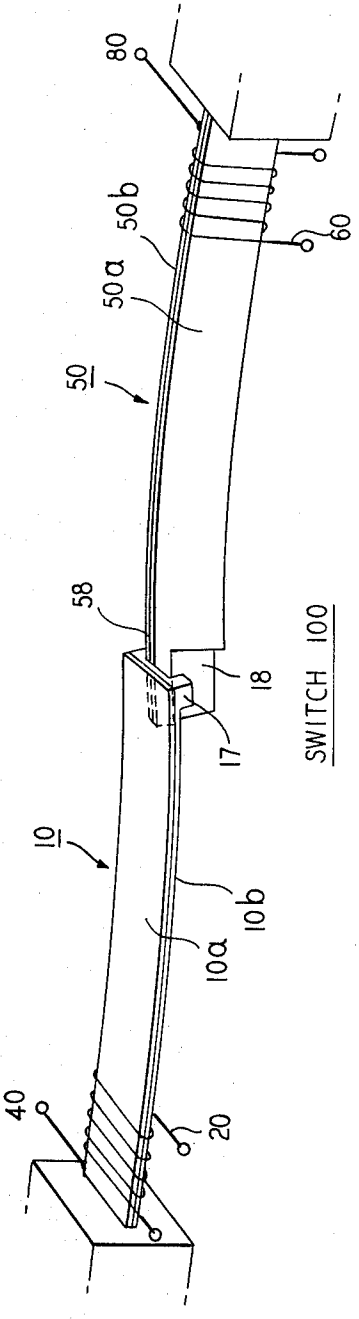


FIG. 7

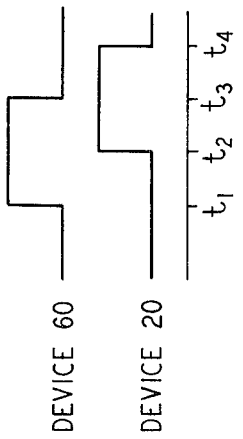
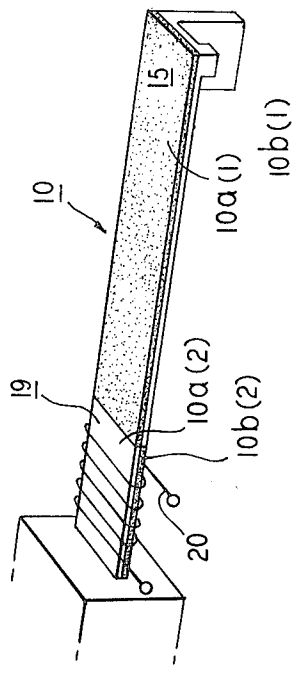


FIG. 6



LATCHING SWITCH

BACKGROUND OF THE INVENTION

This invention relates to latching switches and, more particularly, to latching switches adapted fo use in crosspoint matrices.

In crosspoint matrices, the time necessary to operate, i.e. to open or close, a selected crosspoint is often negligible compared to the time the crosspoint is to remain closed. Accordingly, economical operation of the matrix requires that no "holding power" be expended in maintaining crosspoint closure. To this end, arrangements have been devised in which each crosspoint comprises a latching switch. The contact elements at a crosspoint latch mechanically when deflected and released in a prearranged sequence so that expenditure of holding power is obviated.

In such known crosspoint matrices, deflection and release of the latching switch contact elements is generally effected via electromechanical actuating apparatus such as relays, solenoids, and push rods. Although generally satisfactory, the actuating apparatus tends to be bulky and expensive as compared to the contact elements themselves.

Typically, actuation of one or the other of the contact elements of known latching switches causes the switch, if closed, to open. Thus, operation of a particular crosspoint in a row-and-column operated matrix may open a previously closed crosspoint. Accordingly, row and column operation of known crosspoint matrices is precluded where two or more crosspoints in a given row or column are to be sequentially operated for concurrent closure.

SUMMARY OF THE INVENTION

Accordingly, a general object of the invention is to provide an improved latching switch.

A more specific object of the invention is to provide an improved latching switch adapted for use in crosspoint matrices.

A further object of the invention is to provide an improved latching switch having simple, compact and economical actuating apparatus.

Yet another object of the invention is to provide an improved latching switch which remains closed notwithstanding independent operation of one or the other of its contact elements.

In a latching switch comprising first and second resilient contact elements, these and other objects are achieved by utilizing a bimetal for the contact elements and by adapting the elements such that both must be operated in a prearranged sequence to close the switch. Each bimetallic contact element has an electrothermal actuating device associated therewith and bends toward its "deflection" face, i.e. deflects, when subjected to a temperature change. As an element returns to ambient temperature, it bends toward its "release" face, i.e. releases. The bimetallic contact elements are normally electrically isolated from one another. The free ends thereof deflect and release in substantially orthogonal directions, the first element being adapted for release into the release path of the second element. Subsequent release of the second element thus establishes contact between the first element and the release face of the second element.

In an illustrative embodiment of the invention the first element has a contact finger which, when the first element is deflected, passes over and forward of the second element. The second element is then deflected, a stop extending from its release face thereby being positioned to obstruct the release path of the first element contact finger. When the first element is released, the contact finger passes under a boss extending from the release face of the second element but encounters the stop. The finger is thus stopped in a position obstructing the release path of the second element. Consequently, when the second element is released, the contact finger of the first element is engaged between the boss and the stop. The first and second elements are thus establishdd in a latched configuration. The switch is reopened by reversing the deflection and release steps outlined above.

In accordance with an important aspect of the invention, switch closure is maintained if either element is actuated independently, as might be the case in a row-and-column operated crosspoint matrix. If the first element is actuated its contact finger encounters the boss on the second element and it is thereby prevented from deflecting out from under the second element. If the second element is actuated, the stop thereon maintains contact with the contact finger of the first element.

BRIEF DESCRIPTION OF THE DRAWING

These and other objects and aspects of the invention may be clearly understood from the following detailed description and accompanying drawing in which:

FIGS. **1–5** are views of an illustrative embodiment of a latching switch according to the invention;

FIG. **6** shows a temperature compensated contact element for the present latching switch; and

FIG. **7** is a time chart illustrating the sequencing of signals for actuating devices utilized in the latching switch of FIGS. **1-5.**

DETAILED DESCRIPTION

Latching switch **100,** shown in FIGS. **1–5,** is comprised of resilient contact elements **10** and **50** which are secured at respective fixed ends **19** and **59** to support **30** and **70.** Element **10** comprises metallic deflection and release faces **10***a* and **10***b*, respectively, and element **50** comprises metallic deflection and release faces **50***a* and **50***b*, respectively. Illustratively, the thermal expansion coefficients of deflection faces **10***a* and **50***a* are small as compared to the thermal expansion coefficients of release faces **10***b* and **50***b*, respectively. Thus, it will be appreciated that elements **10** and **50** are each comprised of a bimetal which bends toward its deflection face, i.e. deflects, when heated, and which bends toward its release face, i.e. releases, when returned to ambient temperature.

At ambient temperature, elements **10** and **50** assume the undeflected positions shown in FIG. **1** and thus are normally electrically isolated from one another. As the temperature of element **10** is increased, its free end **15** deflects toward deflection face **10***a*, as indicated in FIG. **1.** Similarly, as the temperature of element **50** is increased, its free end **55** deflects, as indicated in FIG. **1,** in a direction substantially orthogonal to the deflection of element **10.**

The temperature of each element is regulated via a pair of electrothermal actuating devices, illustratively heating devices **20** and **60,** which are adjacent fixed ends **19** and **59** of elements **10** and **50,** respectively. Thus, it is seen that the present invention advanta-

geously obviates the requirement heretofore for bulky and relatively costly electromechanical contact element actuating apparatus. Free end **55** of element **50** terminates in a contact finger **56**, and when elements **10** and **50** are in the undeflected positions of FIG. **1**, finger **56** is illustratively above and behind element **10**. Accordingly, either of elements **10** or **50** may be deflected and released without contacting the other. External terminals **40** and **80** are electrically connected to elements **10** and **50**, respectively. Thus, switch **100** is open as long as elements **10** and **50** are electrically isolated and not in contact with one another.

Switch **100** is closed by applying actuating signals to heating devices **20** and **60** in the sequence indicated in FIG. **7**. At time t_1, current is applied to heating device **60**. As element **50** deflects in response to the heat thus generated, finger **56** passes over element **10** and forward of front edge **16** thereof, thereby assuming the position shown in FIG. **2**.

Thereafter, and while element **50** is still in the deflected position depicted in FIG. **2**, current is applied to heating device **20** at time t_2. Element **10** deflects upward, as shown in FIG. **3**, such that the lower edge of boss **17** extending from release face **10b** is higher than the upper surface **58** of finger **56**. Thus, when current for heating device **60** is terminated at time t_3, finger **56** passes under boss **17**. However, as shown in FIG. **4**, element **50** is prevented from fully returning to its undeflected position because finger **56** encounters stop **18**, which extends from release face **10b** into the release path of finger **56**. Finger **56** is thus stopped in a position obstructing the release path of element **10**. At the same time, the contact of finger **56** and stop **18** establishes electrical connection between terminals **40** and **80**, thereby closing switch **100**.

When current for heating device **20** is terminated at time t_4, element **10** begins to return to its undeflected position, but encounters finger **56** which is now in its release path. Thus, elements **10** and **50** are established in the latched configuration shown in FIG. **5**. Elements **10** and **50** may be unlatched, when it is desired to open switch **100**, by reversing the deflection and release steps outlined above.

In accordance with an important aspect of the invention, actuating, i.e. heating, one of the contact elements when the switch is latched (FIG. **5**) does not cause it to open. If, for example, element **10** is heated so that it deflects to the position shown in FIG. **4**, contact is nonetheless maintained between finger **56** and stop **18**. If, on the other hand, element **50** is heated, (starting again from the latched configuration of FIG. **5**) finger **56** is prevented from deflecting out from under element **10** by boss **17**. Accordingly, contact is maintained between element **10** and upper surface **58** of finger **56**.

This last-mentioned aspect of the present latching switch renders its use as a crosspoint particularly advantageous in a row-and-column operated matrix. In such an arrangement, the finger-carrying elements (such as element **50** of switch **100**) in a given crosspoint row are operated in tandem. In a given crosspoint column, the elements which latch with the finger-carrying elements (such as element **10** of switch **100**) are similarly operated in tandem. Thus, a particular crosspoint is opened or closed by operating, in the proper sequence, the row and column of contact elements which define that particular crosspoint. Since, as discussed above, heating of only one of the elements of the present latching switch does not open the switch if it is closed, any crosspoint in the matrix can be operated without causing previously-closed crosspoints to open. Moreover, since either of the latching switch contact elements can be deflected when the switch is open (as in FIG. **1**) without contacting the other element, operation of a particular crosspoint in the matrix will not result, even momentarily, in unwanted closure of a crosspoint in the same row or column.

FIG. **6** shows a scheme which provides compensation for variations in ambient temperature of elements **10** and **50**, which variations may cause unwanted deflection of those elements. The deflection face of element **10** includes sections **10***a*(1) and **10***a*(2) and its release face includes sections **10***b*(1) and **10***b*(2). Illustratively, the thermal expansion coefficients of sections **10***a*(1) and **10***b*(2) are greater than those of sections **10***b*(1) and **10***a*(2), respectively. Since variations in ambient temperature will be substantially uniform across element **10**, the tendency of free end **15** to bend in one direction will normally be offset by the tendency of its fixed end **19** to bend in the other direction. However, when current is applied to heating device **20**, fixed end **19** is heated to a greater extent than free end **15** and element **10** will deflect upward as in FIGS. **3** and **4**. Of course, a similar temperature compensation scheme can be implemented for element **50**.

It is to be understood that the foregoing merely illustrates the principles of the invention. For example, if it is not necessary in a particular application that switch closure be maintained upon actuation of one of the contact elements, boss **17** and stop **18** of element **10** can be eliminated therefrom with element **50** then being positioned when the switch is open such that finger **56** is directly over element **10**.

Furthermore, alternative heating devices may be employed to heat and thus deflect the contact elements of the switch. For example, an insulating layer might be placed on deflection faces **10***a* and **50***a* of elements **10** and **50** and a resistor printed on each insulating layer, current then being applied to the resistor to heat the associated element.

Thus, it will be appreciated that further modifications and embodiments of the invention may be devised by those skilled in the art without departing from the spirit and scope thereof.

I claim:

1. A latching switch comprising first and second bimetallic contact elements each having a fixed end and a free end, means for supporting each of said elements at its fixed end to normally electrically isolate said elements from one another, actuating means including means for regulating the temperature of each of said elements for deflecting and releasing said elements individually to move said free ends in substantially orthogonal and intersecting paths, and stop means extending from said free end of said second element and adapting said free ends for mutual engagement in a latched configuration at the intersection of said paths, said stop means operative in said latched configuration for obstructing the release path of said first element when said second element is fully deflected in a direction away from said first element, whereby deflection and subsequent sequential release of said first and second elements engages said free ends thereof in said latched configuration, said free end of said first ele-

ment contacting said free end and said stop means of said second element.

2. A latching switch in accordance with claim 2 wherein said free end of said second element further includes boss means for obstructing the deflection path of said first element when said first and second elements are engaged in said latched configuration, said boss means extending from said second element in the same direction as said stop means, whereby disengagement of said latched configuration by subsequent deflection of said first element is prevented.

3. A latching switch in accordance with claim 2 wherein said free end of said first element includes a finger adapted for contact with said free end of said second element between said stop means and said boss means.

4. A latching switch comprising first and second bimetallic contact elements each having a fixed end and a free end, said free end of said first element including a contact finger extending therefrom in a direction away from said fixed end of said first element, means for positioning said finger above and behind said second element, first temperature regulating means for deflecting said free end of said first element to position said first element free end in front of said second element, second temperature regulating means for deflecting said second element to position said free end of said second element above said free end of said first element, and means disposed on said second element for stopping release of said first element in a position obstructing the release path of said second element, said stopping means including stop means extending from said second element for obstructing the release path of said first element finger when said second element is fully deflected upward from said first element.

5. A latching switch in accordance with claim 4 further including boss means extending from said second element for obstructing the deflection path of said first element finger when said first and second elements are in said latched configuration.

6. A latching switch comprising first and second contact elements each having a fixed end and a free end, the free end of said first element terminating in a contact finger normally positioned above and behind the free end of said second element, means for deflecting said first element so as to position said finger in front of said free end of said second element, means for deflecting said second element to position said free end of said second element above said finger, stop means extending from said free end of said second element operative when said second element is in a deflected position for stopping release of said contact finger of said first element in a position obstructing the release path of said second element such that deflection and subsequent release of said first and second elements in a predetermined sequence establishes said free end of said second element and said finger of said first element in a latched configuration, and boss means operative when said first and second elements are established in said latched configuration for preventing deflection of said first element finger from the release path of said second element.

7. A latching switch comprising first and second contact elements each having a fixed end and a free end, means for actuating said elements individually such that said free ends deflect in substantially orthogonal and intersecting paths, means adapting said free ends for mutual engagement in a latched configuration at the intersection of said paths, said adapting means stopping said first element in the release path of said second element, the improvement comprising means for preventing unlatching of said elements from said latched configuration in response to actuation of said first element, said preventing means including boss means disposed on said second element and operative when said first and second elements are engaged in said latched configuration for obstructing the deflection path of said first element.

8. A latching switch in accordance with claim 7 further comprising additional means for preventing unlatching of said elements from said latched configuration in response to actuation of said second element, said additional means including said adapting means operative when said second element is in a deflected position for obstructing the release path of said first element.

9. A latching switch in accordance with claim 7 wherein each of said contact elements comprises a bimetal and said actuating means includes means for regulating the temperature of each of said elements.

* * * * *