June 7, 1966 K. R. McKEE 3,255,318

CROSS BAR SWITCH WITH SEQUENTIAL OPERATOR MOVEMENT

Filed Dec. 11, 1963 3 Sheets-Sheet 1

Fig. 1

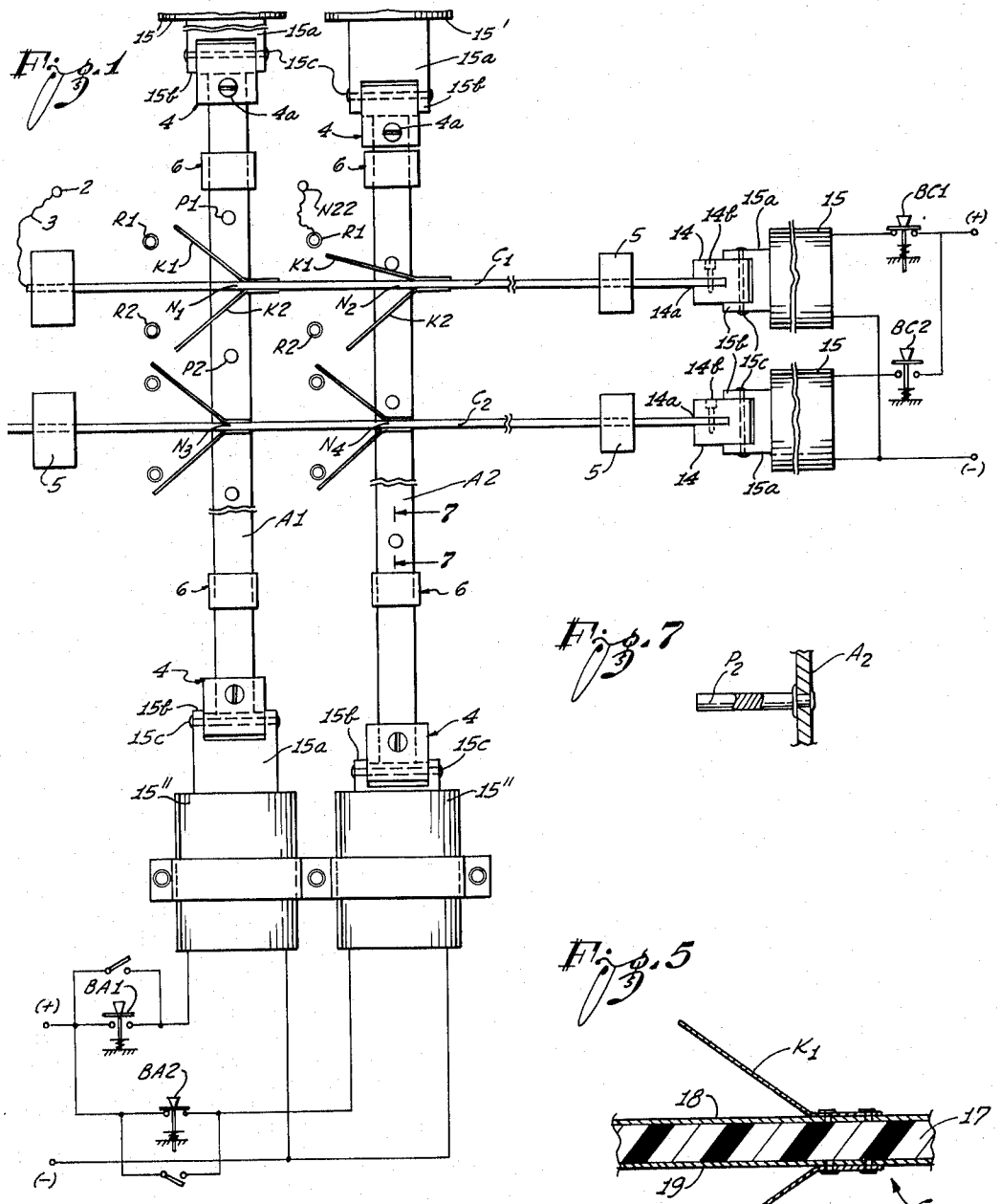


Fig. 7

Fig. 5

INVENTOR:
Kenneth R. McKee

By Smyth, Roston & Pavitt
Attorney

June 7, 1966 K. R. McKEE 3,255,318

CROSS BAR SWITCH WITH SEQUENTIAL OPERATOR MOVEMENT

Filed Dec. 11, 1963 3 Sheets-Sheet 2

Fig. 2

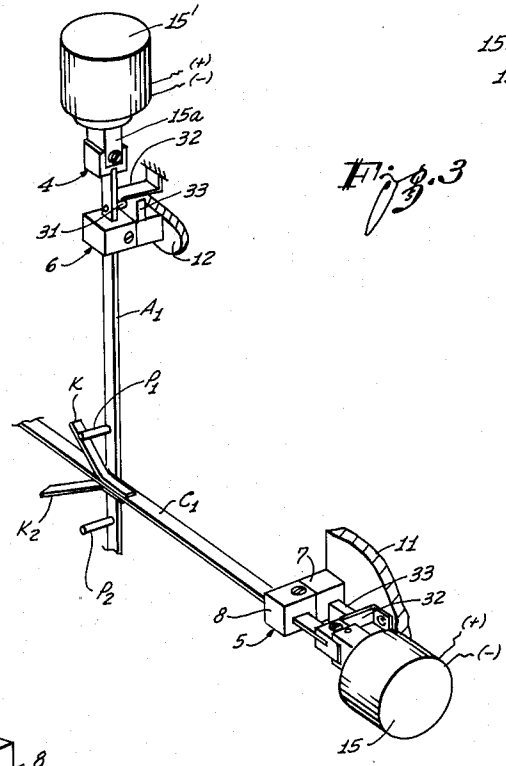


Fig. 3

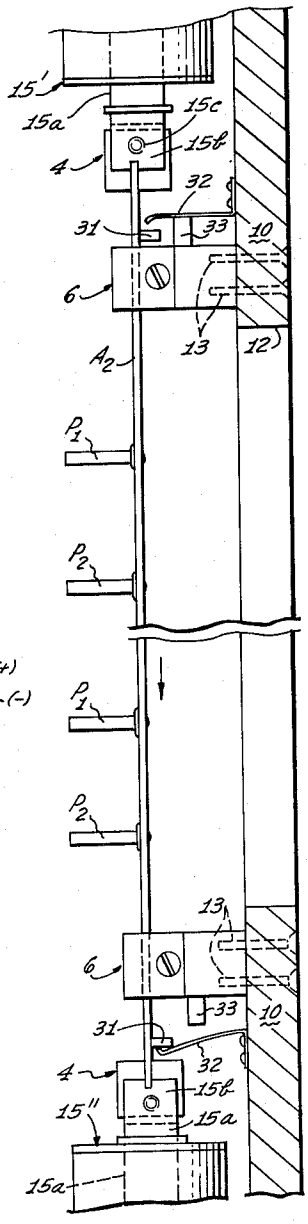
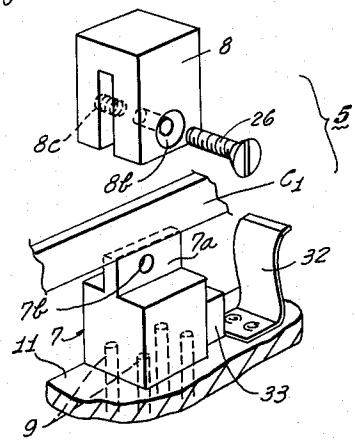


Fig. 4



INVENTOR:
Kenneth R. McKee

By Smyth, Roston & Pavitt
Attorneys

June 7, 1966 K. R. McKEE 3,255,318

CROSS BAR SWITCH WITH SEQUENTIAL OPERATOR MOVEMENT

Filed Dec. 11, 1963 3 Sheets-Sheet 3

Fig. 6a

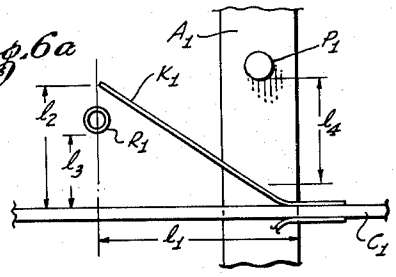


Fig. 6b

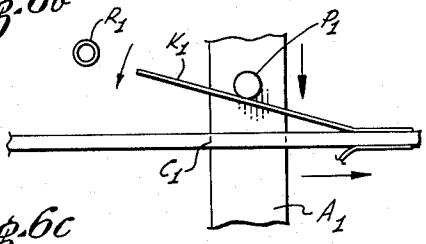


Fig. 6c

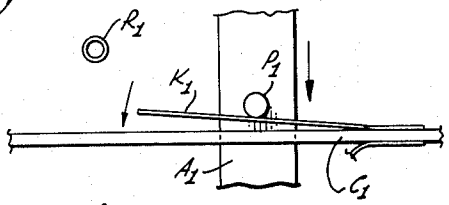


Fig. 6d

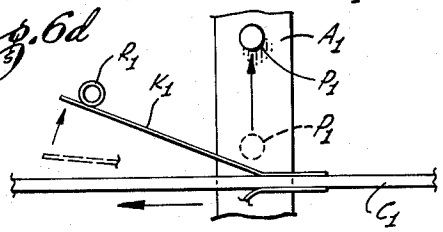


Fig. 6e

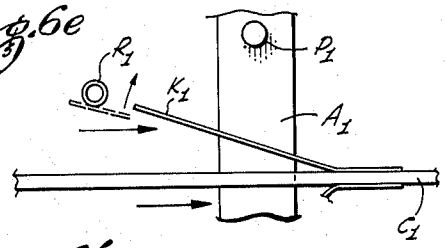


Fig. 6f

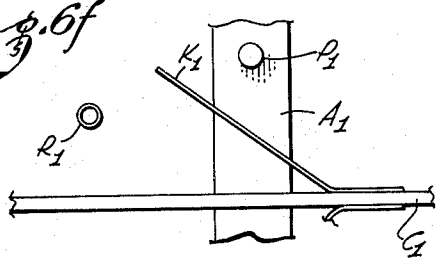
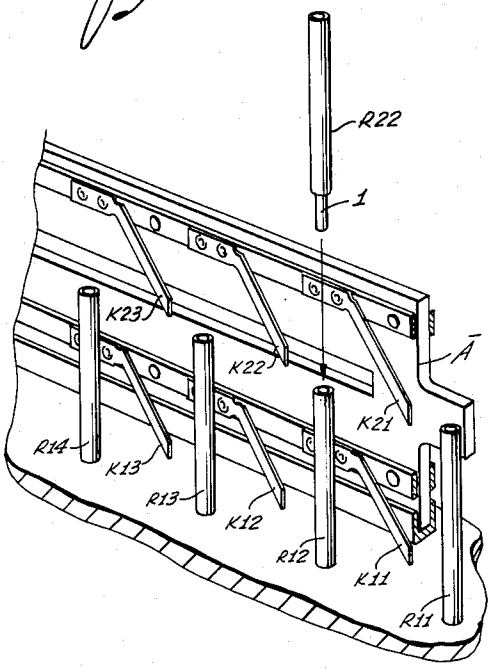


Fig. 8



INVENTOR:
Kenneth R. McKee

By Smyth, Roston & Pavitt
Attorneys

United States Patent Office 3,255,318 Patented June 7, 1966

3,255,318

CROSS BAR SWITCH WITH SEQUENTIAL OPERATOR MOVEMENT

Kenneth R. McKee, Van Nuys, Calif., assignor to McKee Automation Corporation, North Hollywood, Calif., a corporation of California

Filed Dec. 11, 1963, Ser. No. 329,651
10 Claims. (Cl. 200—1)

The present invention relates to a matrix-type selector switching device and to the control of such a device.

A matrix-type selector switch, in accordance with the invention to be described more fully below, can be programmed internally or externally to select and to establish or disestablish a circuit between one line or one group of lines and one of two or more other lines or groups of lines at each crosspoint of the matrix. Through use of a unique contact arrangement in conjunction with stationary contact rods mounted on a removable connector unit, the functional capabilities of this selector switch far exceed those of any selector switch known to the prior art.

A typical switch in accordance with this invention can select either one of two single-line or multi-line circuits at each crosspoint of its matrix and connect or disconnect this circuit with respect to a fifth, or common, circuit. For example, a switch having a matrix of ten parallel bars crossing ten other parallel bars has one hundred crosspoints, each formed of a bar and a crossing bar. Each of the matrix bars is mounted for bidirectional displacement from a normal position along a line collinear with its longitudinal axis. Thus, the two bars intersecting at a crosspoint can be displaced selectively and at the same time in any one of two combinations of directions from their respective normal positions. Accordingly, this embodiment of the switch will be capable of selecting any one of two hundred circuits, and establishing or disestablishing a connection between the selected circuit and a common circuit.

A unique contact structure makes it possible to displace the two bars forming each crosspoint simultaneously or sequentially and still obtain quick contact closure and separation in addition to a moderate wiping stroke. Moreover, simultaneous displacement of a pair of crossbars makes it possible to complete a switching action in a time period shorter by milliseconds than the time required for a conventional sequential-displacement crossbar switch to complete an equivalent switching action. The unique contact structure also makes it possible to provide the wide intercontact gaps required for use, for example, in high-voltage insulation leakage tests.

This novel selector switch also includes a removable switch connector unit having a plurality of contact rods which constitute one contact member in each of the switching elements of this switch. The phrase, "switching element," as used here and below, should be understood to means a contact rod in cooperative relation with a resilient contact arm. Thus, one of the two contacts in each of the switching elements at each crosspoint of the matrix is a contact rod of the removable connector unit. This feature virtually eliminates the necessity of internal switch wiring for all applications envisioned for this switch, and makes it possible to achieve internal programming of switching action either through the use of an insertable punched card or extensible contact rods. The unique contact structure further permits pulse actuation of the matrix bars, so that they are in a normal or resting position for as long as a contact or contacts remain open or remain closed while appropriate and selected bars are being moved for contact-opening and closing actions. It is a further feature of the present invention that due to the resilient cooperation between

contact arm and contact rod, contact making requires operative movement of the two intersecting matrix bars, whereas contact breaking requires only the movement of one bar.

By slightly modifying the switching elements, this selector switch can open, for example, any one of two normally closed switching elements at a selected crosspoint of the matrix. Hence, if the switch has one hundred crosspoints, two hundred switching elements may be normally closed, but selective displacement of two intersecting bars will open a selected one of the closed elements.

In a further modification of this selector switch, the switching elements of the matrix are designed to enable two connector units to be coupled to opposite sides of the same matrix. With this arrangement, it is possible to close or open any one of four circuits between coaxially aligned contact rods at each crosspoint.

In general, the many functional advantages of a selector switch in accordance with this invention are derived from the use of an ingenious matrix contact-arm assembly in conjunction with a switch connector unit having contact rods which extend into the assembly. The contact rods serve as external line connectors and as stationary contacts for the switching elements associated with each crosspoint. The contact arms constitute the movable contact for each switching element.

The matrix is formed from first and second sets of spaced-apart parallel bars. The bars of the first set lie in a first common plane, and bars of the second set lie in a second common plane parallel to and beside the first plane. The bars of the first set extend in perpendicular relation to the bars of the second set, so that crosspoints will be formed at each crossing of a bar of one set with a bar of the other. Each bar of the matrix is mounted for longitudinal and bidirectional displacement from a normal position. Two contact arms made of elongated, resilient, highly conductive material are coupled to each side of a bar at each crosspoint, so that one contact arm will extend from one side of the bar in crossing relation with respect to the other bar of the crosspoint, and the other contact arm may have a symmetrical orientation on the other side of the bar. Two actuator pins are mounted on the other bar respectively adjacent to the contact arms, so that displacement of the latter bar will cause one of the actuator pins to move into deflecting position with respect to its adjacent contact arm. Movement of the actuator pins alone, however, will be insufficient to permanently deflect the contact arms to operate a switching element continuously; the bar on which the contact arms are mounted also must be displaced temporarily in order to deflect one of the arms far enough to lock to the switching contact rod.

The ingenious structure of the contact-arm assembly makes it possible to provide wide spacing between the contact surfaces of the contact arms and the bars of the matrix. As a result, the contact rod-connector unit may be removed and replaced in its position on the matrix with little likelihood of deformation or other damage to the contact arms or contact rods. A further advantage is the fact that several contact rod-connector units can be used and interchangeably connected rapidly and easily to the same matrix. In doing this, a number of single or multiple circuits, equal to two times the number of crosspoints in the matrix, may be connected or disconnected at the same time from the selector switch. Moreover, this connection or disconnection does not require the use of large pushing or pulling forces to overcome frictional engagement between connector pins and their respective receptacles, as would be the case if a connector unit of conventional design were to be used. This, then, is another important feature, one which makes it possible to achieve

almost friction-free installation and removal from the switch of a single connector having an indefinitely large number of lines and contact rods. It is this feature which enables users of this novel selector switch to set up and conduct tests involving large numbers of conductors with a rapidity and flexibility of programming unknown to the prior art.

Since, for contact making, the movement of two bars is required, the bars carrying the contact arms can be provided with several mutually insulated rows of pairs of contact arms, there being then a corresponding plurality of matrices with a corresponding multiplicity of crossbars.

In this case, a multiplicity of congruent matrices are being arranged side by side so that corresponding crosspoints of each are in collinear relation, and a single connector unit may be provided having contact rods which extend through each matrix. A selector switch in accordance with this arrangement makes it possible to program the matrices for selecting simultaneously a number of contact pins of the connector unit up to the number of matrices.

The term "crossbar" has been used extensively to designate selector switches of the matrix type. A conventional crossbar switch, for example, may be comprised of spaced-apart horizontal bars and spaced-apart vertical bars disposed so that the horizontal and vertical bars are in crossing relation. In this manner, a matrix of crosspoints is formed. Each crosspoint is made up of a single horizontal and a single vertical bar. Each horizontal and vertical bar is mounted for displacement from a normal position along its longitudinal axis, and one or more electrical contacts may be affixed to each bar comprising a crosspoint. The switching elements at each crosspoint may be arranged to be normally closed or normally open when the bars are in their normal position and to be in their opposite state when both bars of the crosspoints are in their displaced position.

In conventional crossbar switches, the design of the switching element at each crosspoint requires sequential displacement of the bars of the crosspoint in order to achieve effective switching action. In addition, only a single switching element can be provided at each crosspoint, and the dimensions of the gap between contact surfaces of each switching element must necessarily be kept small in order to achieve switching times short enough for many important applications.

The principal mode of operation of the conventional crossbar switch is analogous to the switching action of an ordinary rotary switch, but the latter is subject to many disadvantages which are not present in the former. For example, the time required to select and switch any switching element of the crossbar switch may be made constant, while the times required for selection and switching in an equivalent rotary switch are variable. Unlike a rotary switch, a crossbar switch may operate a selected circuit directly, without being subject to the disadvantage of momentarily operating one or more intermediate switching elements, as must be done in the case of the rotary switch when its common contact is rotated to a remote contact position.

More generally, a crossbar switch is the operational equivalent of a large network of switching relays. Here again, the crossbar switch is superior. For example, less power is required because the crossbar switch requires only that two bidirectional coils be energized in order to effect switching action at any one of the crosspoints of a matrix. In contrast, a relay network may require energization of a large number of relay coils to effect many equivalent switching actions. In addition, the crossbar switch requires less space, and eliminates the expensive and time-consuming buss-bar wiring techniques normally required for operation of relay networks at low voltage and current levels.

Although the advent of the conventional crossbar switch eliminated many disadvantages which arose from the preexisting necessity of using either a rotary switch or a relay network, it is itself subject to many limitations. Among these is the requirement of sequential displacement of the crossbars at the selected crosspoint in order to achieve reliable and serviceable switching action at reasonable cost. This requirement, of course, imposes severe limitations on the spacing of the contacts of switching elements and the time required to effect switching action. In addition, the presence of only one switching element per crosspoint limits the switching capacity of a crossbar matrix. It is the limitation in gap size and the resulting likelihood of arcing at the required high voltage that makes conventional crossbar switches unsuitable for use in the performance of insulation leakage tests. A further disadvantage of conventional crossbar switches has been the comparative unreliability of switching elements. This has been caused in part by the ease with which the contacts of switching elements may become misaligned.

A matrix-type selector switch in accordance with this invention may embody all of the advantages of conventional crossbar switches while eliminating virtually all of their disadvantages and adding thereto the possibility of pulse actuation. For example, a unique contact design makes it possible to mount sets of switching elements at each crosspoint of a matrix or matrices. Other advantages attributable to the uniquely designed contact structure of the switching elements are an increased gap width, without undue lengthening of the time required to effect switching action, and enhancement of reliability on account of elimination of the requirement for precise mechanical alignment of contact surfaces. The power required for a switching action also is minimized on account of the use of elongated resilient contact arms. And the bars of any crosspoint may be actuated substantially simultaneously in order to minimize the time required for a switching action.

Other features and advantages of a matrix-type selector switch in accordance with this invention are attributable principally to an ingenious connector unit comprising extended contact rods. Each contact rod constitutes a stationary contact for each switching element or elements in case of multiple matrices. Thus, internal switch wiring becomes unnecessary. Once the contact rod-connector unit is installed on the matrix, the switch is internally wired and ready for use. Because the connector unit is an integral part of the selector switch, minimal force is required to install or remove this unit.

In effect, the matrix scans the contact rods directly. Inasmuch as the contact rods are, in fact, the connector pins which connect the electrical circuits to the selector switch, the necessity for multiple input connectors on the matrix frame and a large number of conductors or busses to the individual switching elements is wholly eliminated. A further advantage derived mainly from use of this ingenious connector unit of the capability of internal programming through the use of punched cards or extension pins in a manner explained in further detail below. It should be noticed, of course, that the aforementioned features and advantages of the selector switch of this invention make it possible to improved maintainability and to reduce markedly the space required in comparison with that occupied by a conventional crossbar switch having an equal switching capacity.

While the specification concludes with claims particularly pointing out and distinctly claiming the subject matter which is regarded as the invention, it is believed that the invention, the objects and features of the invention, and further objects, features, and advantages thereof will be better understood from the following description taken in connection with the accompanying drawing, in which:

FIG. 1 is a top view of a portion of a switching matrix according to a preferred embodiment of the present

invention and includes a circuit diagram for controlling switching actuation;

FIG. 2 illustrates in perspective view one actuator bar with actuating solenoid, one contact carrier bar also with actuating solenoid, and a contact means at their crosspoint;

FIG. 3 illustrates in side elevation an example of an actuator bar and its supporting structure;

FIG. 4 illustrates an exploded and perspective view of the supporting structure for a carrier bar;

FIG. 5 illustrates in cross-sectional view a portion of a carrier bar with two contact arms attached thereto;

FIGS. 6*a* through 6*f* illustrate various phases of contact making and breaking at one matrix crosspoint;

FIG. 7 is an enlarged cross-sectional view of an actuator pin and its support on an actuator bar; and

FIG. 8 is a perspective view of a modified contact-arm carrier bar.

A matrix-type selector switch in accordance with this invention may be comprised of a matrix made up of two actuator bars A1 and A2 and two contact carrier bars C1 and C2 arranged to form crosspoints N1, N2, N3, and N4; two stationary contact rods R1 and R2 are shown representatively and for each of the crosspoints N1, N2, N3, and N4; two resilient contact arms K1 and K2 secured to the carried bars C1 and C2 also pertain to each crosspoint N1, N2, N3, and N4 for cooperative relation to the contact rods R1 and R2, respectively; actuator pins P1 and P2 are secured to the actuator bars A1 and A2, and in cooperative relation with the contact arms K1 and K2 at each crosspoint; and solenoids 15 are coupled to the extremities of carrier bars C1 and C2, and solenoids 15′ and 15″ are coupled to actuator bars A1 and A2 for displacing these bars selectively and bidirectionally from their respective normal, or "resting," positions. There are spring-biased push buttons BA1, BA2, BC1, and BC2 to close energizing circuits for the various solenoids. There are corresponding push buttons for operating solenoids 15′. Each of the push buttons may be shunted by a contact blade for controlling the solenoids otherwise than through manually pressing selected buttons.

The carrier bars C1 and C2 are disposed in mutually spaced-apart and parallel relation, and the actuator bars A1 and A2 likewise are in mutually spaced-apart and parallel relation. The carrier bars C1 and C2 are arranged perpendicularly to the actuator bars A1 and A2. This arrangement constitutes a matrix having four crosspoints N1, N2, N3, and N4. It should be understood, of course, that the matrix may have any number of actuator bars A1 . . . A*n* and any number of carrier bars C1 . . . C*m*, where *n* and *m* represent integers, which do not have to be equal. Furthermore, the number of crosspoints of any matrix usually will be equal to the product of *n* and *m*. For example, a given matrix may have eight actuator bars and eleven carrier bars. If each of the carrier bars crosses each of the actuator bars, this matrix will have eighty-eight crosspoints.

The carrier bars C1 and C2 are slidably supported adjacent to their respective extremities on bearing blocks 5, secured fixedly in position on opposite side members 11 of a suitably shaped, for example, rectangular, frame 10. As a result, the carrier bars C1 and C2 are disposed to be moved bidirectionally along their longitudinal axes.

The actuator bars A1 and A2 likewise are mounted for bidirectional movement along their respective longitudinal axes in bearing blocks 6, secured, in turn, to opposite side members 12 of the same rectangular frame 10.

A suitable mounting structure for the actuator and carrier bars is represented in FIGS. 3 and 4. The general requirements for this mounting structure are that it have means for slidably supporting each of the actuator bars A and the carrier bars C on a frame 10, that it have further means to establish a normal, or undisplaced, position of each bar, and that it include suitable stops to limit the amplitude of the displacement in either of the two longitudinal directions from the normal position.

A structural arrangement for achieving these objectives, applicable to both the actuator bars A and the carrier bars C, is depicted in FIGS. 2, 3, and 4. In FIG. 3, the actuator bar A2 is shown mounted slidably in identical bearing blocks 6, secured by screws 13 to the upper and lower frame members 12 of frame 10. The extremities of the actuator bar A2 are coupled to the plungers 15*a* of solenoids 15′ (upper) and 15″ (lower) by coupling blocks 4, and the extremities of the carrier bars C1 and C2 are secured to the plungers 15*a* of solenoids 15 by coupling blocks 14 (FIGS. 1 and 2). Two stop pins 31, secured to the actuator bar A2 in a position between bearing blocks 6 and couplings 4, limit the amplitude of displacement in either direction. Leaf springs 32 are secured to frame members 12 to exert force in opposite directions against stop pins 31. Each bearing block 6 is provided with a boss 33 against which the springs 32 rest whenever actuator bar A2 is in its normal position.

Thus, in FIG. 3, when lower solenoid 15″ is energized to displace actuator bar A2 downwardly from its normal position, the lower spring 32 likewise is deflected downwardly while the upper spring 32 rests against boss 33. When the lower solenoid 15″ is de-energized, the lower spring 32 operating against the lower stop pin 31 will exert a force against bar A2 sufficient to return it to its normal position. Likewise, actuation, of the upper solenoid 15′ will displace the actuator bar A2 upwardly, so that the upper stop pin 31 will engage and deflect the upper return spring 32. The amplitude of the upward displacement will be limited by the lower stop pin 31 when it engages the lower surface of bearing block 6.

As portrayed in FIG. 1, the coupling blocks 14 comprise a generally rectangular piece of metal or plastic secured to the yokes 15*b* of solenoid plungers 15*a* by the pin 15*c*. A recess 14*a* is provided in the opposite surface of each block 14 to accommodate the ends of carrier bars C1 and C2. Threaded screws 14*b* having smooth shank portions engage the ends of carrier bars C1 and C2 to secure them in position in recesses 14*a*.

The coupling blocks 4 fasten the ends of actuator bars A1 and A2 to the yoke 15*b* of the plungers 15*a* of solenoids 15. The blocks 4 are like the blocks 14, except that the recesses for receiving the ends of carrier bars C1 and C2 are parallel to pins 15*c* rather than perpendicular as in the former case, and the screws 4*b* are perpendicular rather than parallel as in the case of screws 14*b*. It is significant that the carrier bars are being actuated only by one solenoid each.

The structural details of the bearing block 5 for the carrier bars C are represented in FIG. 4 as being comprised of a base 7 and a clamp 8. The base 7, secured to the side members 11 with screws 9, for example, has a flange 7*a* longitudinally disposed across its upper surface and a boss 33 which limits the return springs 32 and establishes the normal, or undisplaced, position of a carrier bar such as C1. The clamp 8 of bearing block 5 is provided with a rectangular longitudinal slot formed in its lower surface. This slot is long enough to accommodate the width of the rectangular carrier bar C1 and flange 7*a* so that the former will be held in firm but slidable engagement within the assembled bearing block 5. The clamp 8 is provided with a hole 8*b* mating with hole 7*b* of the base member 7 and a threaded hole 8*c* to accommodate the mating threads of screw 26. The bearing blocks 5 may be molded from nylon or Teflon, or similar electrical insulating materials. It should be understood, of course, that the only essential difference between the bearing block 5 for providing slidable support for the carrier bars C and the bearing block 6 for supporting actuator bars A is that, in the former case, the clamp 8 would be provided with a T-shaped slot, so that

the broad dimension of the actuator bars A will ben generally parallel to the surface of frame 10.

As shown specifically in FIG. 5, each carrier bar C comprises a flat, rod-shaped backing member 17 consisting of insulating material, for example, nylon, Teflon, or the like. At both sides of this backing member 17, there are provided contact strips 18 and 19, respectively. Contact arms such as K1 and K2 are respectively secured to strips 18 and 19.

The resilient contact arms K1 and K2, made of electrically conductive material, are secured to the carrier arms such as C1 and C2 at each of the crosspoints such as N1, N2, etc. The contact arms K1 and the contact arms K2 are secured in spaced-apart relation and above one of the actuator bars A1 or A2. An actuator pin P1, having one end secured to an actuator bar such as A1 or A2, extends transversely to all bars A1, A2, C1, and C2 and in adjacent and spaced-apart relation to the contact arm K1. Likewise, an actuator pin P2 is disposed on an actuator bar in similar relation to the contact arm K2.

A typical actuator pin P2 is represented in FIG. 7 as being comprised of a short length of cylindrical rod, having one end of reduced diameter, inserted through a hole in the actuator bar A2. The projecting end of pin P2 is then secured firmly to the bar. The pin P2 may be made of a nonconductive material, or if actuator bar A2 is itself made of nonconductive material, the pin P2 may be made of metal or any other conductive material.

Two contact rods R1 and R2 are disposed at each of the crosspoints such as N1, N2, etc. The rods R1 and R2 are placed in symmetrical relation to the extension of a carrier bar onto a line running through the crosspoints N1 and N2. Rods R1 and R2 are normally located in spaced-apart relation with respect to the contact arms K1 and K2, respectively. Any one of the two contact rods R1 and R2 and its associated contact arms K1 and K2 constitutes a switching element. Hence, two switching elements K1–R1 and K2–R2 are present at each of the crosspoints N1, N2, N3, N4, etc. The position of a contact arm such as K1 relative to contact rod R1 and actuator pin P1 is such that, for contact making, bar C1 has to move to the right (in FIG. 1) and bar A1 has to move down prior to actual contact making, which will be explained more fully below. Any downward movement of pin P1 without previous movement of a carrier bar to the right will not produce any contact making.

The solenoid 15 as coupled to one extremity of the carrier bars, such as C1 and C2, serves for displacing each bar from its normal position to the right (in FIG. 1). The solenoids 15 have their plungers 15*a* secured to carrier bars C1 and C2 via coupling blocks 14, as stated.

The solenoids 15′ and 15″ preferably are programmed through the use of circuitry (not shown) which permits the displacement of the actuator bars A1 or A2 in only one direction at a time. As can be seen from FIG. 1, the invention incorporates a safety feature in that all of the switching elements R1–K1 can be closed only when switching elements R2–K2 are not being or are not about to be closed concurrently. Accordingly, the invention inherently precludes concurrent closing of two particular switching elements. The displacement of an actuator bar and of a carrier bar is required to close but one of the two switching elements K1–R1 and K2–R2 at any given crosspoint. The particular switching element actuated in this manner will be determined by the direction in which the actuator bar of that particular crosspoint is shifted. FIG. 6*a* illustrates on an enlarged scale the normal or resting position, with no contact being made by switching element K1–R1.

FIG. 6*a* illustrates that in the preferred embodiment there are certain critical relationships between a contact arm such as K1, a contact rod such as R2, an actuator pin such as P1, and the extension of a carrier bar such as C1. The contact arm K1 is to extend from its point of connection to carrier bar C1 for a distance l_1, which is sufficiently large to bring the contact arm K1 into engagement with rod R1. Contact arm K1 furthermore is to extend away from carrier bar C1 so that its tip is spaced apart from bar C1 by a distance l_2, larger than the distance l_3 between rod R1 and bar C1. The distance l_4 between actuator pin P1 and contact arm K1 measured in the direction of pin movement is to be larger than the distance that P1 has to move for completion of contact making, to be described more fully in the next paragraph.

To achieve switching action as between K1 and R1, the lower solenoid 15″ of actuator bar A1 has to be energized by pressing button BA1 to displace bar A1 in a downward direction; the solenoid 15 coupled to the right-hand extremity of carrier bar C1 has to be energized by pressing button BC1 to displace the latter toward the right (FIG. 6*b*). The downward displacement of A1 moved the actuator pin P1 into actuating relation with respect to the contact arm K1, and the displacement of the carrier bar C1 pulled contact arm K1 into deflecting relation against the actuator pin P1 and away from rod R1 to clear the same. Inasmuch as the displaced position of actuator pin P1 is close to the point where contact arm K1 is secured to C1, only a short displacement of the carrier bar C1 is required to effect rapid closing action of K1 across the wide gap of switching element K1–R1.

FIG. 6*c* illustrates that the downward motion of actuator bar A1 with pin P1 continues while button BC1 is released, so that solenoid 15 is being de-energized. Under the influence of the spring 32, which cooperates with carrier bar C1, this latter bar returns now to the left (FIG. 6*d*), whereby contact arm K1 slips in between the space as defined between the bar C1 proper and rod R1. As soon as button BA1 is released, actuator bar A1 returns upwardly and releases contact arm K1; the latter contact arm K1 will now resiliently engage contact rod R1. There will be a slight wiping action as between rod R1 and arm K1. This wiping action is the result of the further displacement of K1 by R1 after first contact occurs with R1, and bar C1 is not yet at rest.

It should be understood, of course, that the wiping stroke is important in effecting a good, noise-free juncture between the contact surfaces of K1 and R1. The wiping stroke also helps to keep these surfaces clean so that their rated resistance will be maintained.

For contact opening (FIG. 6*e*), button BC1 is pressed again, so that solenoid 15 for bar C1 is being energized and shifts to the right. By resilient action alone, arm K1 returns into the contact-open position (FIG. 6*a*), while bar C1 again is returned, also by resilient action of a spring 32. Actuator bar A1 and pin P1 do not participate in this contact-opening action.

Contact closing and opening can be distinguished by bar actuation. For contact closing, the two bars intersectting at a matrix crosspoint have to be moved temporarily out of their normal position. For contact opening, only the carrier bar requires a similar temporary movement. A close study of FIGS. 6*a* through 6*d* reveals that the inventive switching device does not require exclusively pulse operation. For example, the command, or command signal, initially pulling down actuation bar C1 (FIGS. 6*b*, 6*c*) may stay on. The dotted circle in FIG. 6*d* shows that, accordingly, actuator pin P1 can stay in its lower position during contact making. It does not hamper proper operation if the actuator such as pin P1 remains in actuating position, provided that the pin is disengaged from the contact arm and does not urge the contact arm such as K1 away from the cooperating contact rod. In other words, when the carrier bar returns (to the left in FIG. 6*d*), the contact arm must always disengage from the actuator pin. It is immaterial whether this disengagement is due to a combined movement of the

actuator and contact carrier bars, or only due to the return movement of the carrier bar alone.

Next, it is not mandatory that the carrier bar such as C1, when returning for locking a contact arm such as K1 behind a contact rod such as R1, does in fact return to its initial position; and it is even possible that the movement of the carrier bar described above as a return movement is the only movement of the carrier bar.

For example, FIG. 6*f* shows a normal position eventually incorporating a modified contact-arm structure, wherein the contact K1 will clear rod R1 without requiring any preparatory movement of the carrier bar such as C1. In this case, contact making would be carried out by an initial step as indicated in FIG. 6*c*, wherein the actuator pin P1 first bends contact arm K1 down. Subsequently, the actuator bar will be moved to the left (FIG. 6*d*) and will stay in that position. It will be appreciated that, in this mode, the solenoid 15 for the carrier bar is to stay energized for as long as contact making is desired.

The structural modification eventually necessary for this mode of operation relates only to the structural dimensions, such as the length of the contact arm, to insure proper clearance when moved by the actuator pin prior to locking proper.

However, in order to practice the invention with a normal position as shown in FIG. 6*f*, it is possible to use precisely the same contact-arm structure as is principally shown in FIG. 5. In this case, it is only necessary to mount the carrier bars such as C1 or C2 to assume normal positions, i.e., without solenoid energization, as is shown in FIG. 1 for the displaced carrier bar C1. It is, furthermore, necessary to link solenoids 15 to the carrier bars at the left-hand side, so that a contact-making position such as shown in FIG. 6*d* will be obtained during solenoid energization. Hence, in this case there is no pulse operation as far as carrier bars are concerned. In such a modified embodiment, it is immaterial whether the solenoids 15′ or 15″ are being pulse operated or whether they are maintained in an energized state throughout contact making.

In the following description, it will briefly be explained to what extent the actuator pins do not influence contact arms pertaining to nonselected carrier arms.

As can be seen in FIG. 6*a*, which illustrates, for example,the normal contact-open position in the preferred embodiment of the invention, any downward movement of pin P1 will not deflect contact arm K1, provided the carrier bar is not being shifted to the right. Hence, all contact arms pertaining to crosspoints of the matrix and traversed by actuator bar A1 will not engage their associated contact rods such as R1 unless a carrier bar is being moved to the right concurrently.

In the modified embodiment, as illustrated in FIG. 6*f*, a downward movement of actuator bar A1 will deflect all contact arms K1 pertaining to all the crosspoints as traversed by actuator bar A1. However, in this case, the contact arms K1 clear their respectively associated stationary contact member R1, so that contact making is only carried out when and after a carrier bar has been moved to the left so that the contact arm K1 of one particular crosspoint can assume a position as illustrated in FIG. 6*d*.

In the aforedescribed manner, the displacement of actuator bar A2 in the downward direction, in cooperation with the displacement of the carrier bar C2 toward the right, results in the completion of an electrical circuit from terminal 2 via conductor 3, carrier bar C1, and contact arm K1 to another terminal N22 coupled to contact pin R1. From the foregoing description, particularly of FIG. 6*a* et seq., it will be understood that the operating position for contact arm K2 at matrix point N2 corresponds to the position illustrated in FIG. 6*c*.

The other switching element K2–R2, also being associated with crosspoint N1, may be closed selectively in similar manner. For example, an upward displacement of actuator bar A1 and a temporary rightward displacement of carrier bar C1 will close the switching element K2–R2.

Although it is expected that a carrier bar C1 or C2 and an actuator bar A1 or A2 ordinarily will be displaced simultaneously, this is not essential for satisfactory operation of this selector switch. The switching action can be effected satisfactorily by a sequential displacement in that the movement of the actuator bar succeeds that of the carrier bar. Of course, the actuator bar must be displaced prior to the return movement of the carrier bar. It follows that a switching matix having its switching elements in a zero position, shown in FIG. 6*f*, must be operated in that the carrier bar should not be moved (to the left) prior to the initiation of actuator-bar and pin displacement.

As explained above, a matrix suitable for use with this switch may have any practicable number of carrier bars and an equal or different number of actuator bars. The number of crosspoints formed usually will be equal to the product of the carrier bars and actuator bars, and the number of switching elements which can be accommodated will be two times as large.

Although the embodiments of the selector switch represented in the drawings have single-pole switching elements, it should be apparent that multiple-pole switching elements may be used with only slight modification of the carrier bars, contact arms, and contact rods.

For example, FIG. 8 shows that the width of a carrier bar $\overline{A}$ is being increased sufficiently to accommodate a multiplicity of sets of contact arms, such as K11, K12, K13, etc., and K21, K22, K23, 35*c*. Such an arrangement can be used as double-pole switching elements, in which case all of the contact arms are being interconnected by a common conductor. However, if one keeps the two sets of contact arms separate and insulated from each other, there are in fact established two congruent matrices.

A first series of contact rods R11, R12, R13, etc., could be constructed of hollow, cylindrical material having internal dimensions large enough to accommodate and to receive separate conductors such as R22, having a separated contact surface and being provided at like intervals along the arrangement of hollow rods and in cooperative relation with the upper row of contact arms. Accordingly, arms K11, K12, K13, etc., will individually make contact with rods R11, R12, etc.; and the arms of the upper row, including K22, etc., will make contact with rods such as R22. Rod R22 preferably has insulated portions such as I.

The actuator pins will be lengthened as required in order to effect simultaneous deflection of all of the contact arms of one of the switching elements. Or one has to double the number of actuator pins to establish two complete matrices.

The invention is not limited to the embodiments described above, but all changes and modifications thereof not constituting departures from the spirit and scope of the invention are intended to be covered by the following claims.

I claim:

1. A selector switch comprising:

at least one actuator bar mounted for longitudinal displacement;

at least one carrier bar mounted for longitudinal displacement in crossing relation to said actuator bar to establish at least one crosspoint;

a pin coupled to the actuator bar for displacement therewith;

a contact rod extending perpendicularly to the directions of said displacements, in spaced-apart relation to said bars and at a predetermined distance from said carrier bar;

at least one resilient contact arm made of an electrically conductive material and coupled to said carrier bar for displacement therewith and extending there-

from, with the tip of said contact arm normally being farther apart from said carrier bar than said contact rod;

means coupled to said actuator bar for obtaining selective longitudinal displacement of said actuator pin, to engage said contact arm and deflect same towards said carrier bar so that the tip of said contact arm clears said contact rod and is temporarily closer to said carrier bar than said contact rod; and

means coupled to said carrier bar for obtaining a selective longitudinal displacement thereof to lock said deflected contact arm behind said contact rod.

2. A selector switch comprising:

an actuator bar mounted for longitudinal displacement;

a carrier bar mounted for longitudinal displacement in crossing relation to said actuator bar to form a crosspoint therewith;

a contact arm mounted on said carrier bar for displacement therewith;

actuating means mounted on said actuator bar for displacement therewith;

a stationary contact element disposed in physically displaced relationship to said actuator bar and said carrier bar;

means for temporarily displacing said carrier bar from a first to a second position, said carrier bar when in said first position permitting said contact arm to engage said contact element, said carrier bar when in said second position preventing said contact arm from engaging said contact element; and

means for displacing said actuator bar when said carrier bar is in said second position so that said actuating means displaces said contact arm to engage said contact element upon return of said carrier bar from said second position to said first position.

3. A selector switch comprising:

a plurality of actuator bars disposed in spaced-apart relation;

a plurality of carrier bars disposed in crossing relation with respect to said actuator bars to form a matrix therewith having a plurality of crosspoints;

a plurality of stationary contacts disposed in spaced relationship to said actuator bars and said carrier bars and made of an electrically conductive material;

resilient contact arms made of an electrically conductive material and coupled to said carrier bars in spaced-apart relationship, there being at least one contact arm adjacent to each crosspoint;

means coupled to each carrier bar for temporarily and selectively displacing the bar at the selected crosspoint;

means coupled to the actuator bars for displacing the actuator bar at the selected crosspoint; and

means movable with the actuator bars for obtaining a resilient displacement of one of said resilient contact arms in accordance with the selective displacements of the actuator and carrier bars to introduce said one contact arm into the space as defined between the closest one of said stationary contacts and the carrier bar to which said one contact arm pertains.

4. In a selector switch, the combination comprising:

a plurality of displaceable actuator bars and a plurality of displaceable carrier bars, each having respective normal positions and being mounted in crossing relation to form at least one crosspoint;

at least one switching element at each crosspoint operable selectively in response to various combinations of coexisting displacements from normal positions of the bars of each crosspoint, each of said switching elements including: an elongated, resilient contact arm secured to the carrier bar adjacent to the crosspoint, oriented effectively in crossing relation with respect to the actuator bar of the same crosspoint, and having a contact surface normally inclined to the longitudinal axis of the carrier bar,

a stationary contact member normally disposed on the other side of said contact surface, an actuating pin secured to the actuator bar in actuating relation with the contact arm for moving the latter with respect to the contact member in response to coexisting displacements in respective given directions only of the actuator bar and the carrier bar of the crosspoint from the respective normal positions of the latter bars, so that said contact surface may engage said contact member; and

means for temporarily moving said carrier bar in a longitudinal direction so that said contact arm clears said contact member during actuation by said pin.

5. In a selector switch including a matrix comprising:

a first plurality of displaceable actuator bars;

a second plurality of displaceable carrier bars having respective normal positions and mounted in crossing relation to form a number of crosspoints, which number is the product of said first and second pluralities;

a plurality of normally open switching elements at each crosspoint operable selectively in response to various combinations of coexisting displacements from normal positions of the bars of each crosspoint, each of said switching elements including: an elongated, resilient contact arm secured to the carrier bar adjacent to the crosspoint oriented to extend away from said actuator bar, a stationary contact member spaced apart from and disposed between the arm and the carrier bar, and an actuating pin secured to the actuator bar and extending into a position adjacent the side of the contact arm generally facing away from the carrier bar for deflecting the contact arm towards the carrier bar whenever the actuator bar is being displaced;

means for temporarily displacing a selected carrier bar so that all undeflected contact arms thereon clear the respective stationary contact members with which they cooperate; and

means for displacing a selected actuator bar to move the actuating pins thereon into closer proximity to the associated contact arms, whereby exclusively the contact arm on the selectively and temporarily displaced carrier bar is being deflected and still clears the associated stationary contact member.

6. In a selector switch including a matrix made up of a plurality of displaceable actuator bars and a plurality of displaceable carrier bars having respective normal positions and mounted in crossing relation to form at least one crosspoint, at least one normally open switching element at a crosspoint of the matrix operable in response only to coexisting displacements from the normal positions of the bars of the crosspoint, the said switching element comprising:

an elongated, resilient contact arm secured to the carrier bar adjacent to the crosspoint, oriented with respect to the actuator bar of the same crosspoint in that it extends for a distance l_1 along the latter carrier bar and for a distance l_2 away therefrom and along the latter actuator bar, and having a contact surface facing away from the carrier bar;

a stationary contact member mounted adjacent the carrier bar at a distance l_3 smaller than said distance l_2;

an actuating pin secured to the actuator bar and extending into a position adjacent the side of the contact arm generally facing away from the carrier bar for deflecting the contact arm to place same in between the carrier bar and the contact member whenever the actuator bar and the carrier bar of the crosspoint are displaced in the directions of one combination of coexisting displacements, and the carrier bar being displaced oppositely to the direction of said contact-arm extension along the carrier bar.

7. A selector switch comprising:
at least one actuator bar mounted for longitudinal displacement;
at least one carrier bar mounted for longitudinal displacement in crossing relation to said actuator bar to establish at least one crosspoint;
a pin coupled to the actuator bar for displacement therewith;
a resilient contact arm secured to said carrier bar adjacent said crosspoint and extending at an angle away from said carrier bar;
a stationary contact rod positioned in the space between said carrier bar and said contact arm;
means for longitudinally displacing said carrier bar so that said rod recedes from said space for a distance sufficient to permit angular movement of said contact arm towards said carrier bar and clearing said rod;
means for longitudinally displacing said actuator bar to place said pin into engagement with said contact arm to deflect and urge same towards said carrier bar; and
means for returning said longitudinally displaced carrier bar to shift said deflected contact arm in the space between said stationary contact rod and said carrier bar.

8. A selector switch comprising:
at least one actuator bar mounted for longitudinal displacement;
at least one carrier bar mounted for longitudinal displacement in crossing relation to said actuator bar to establish at least one crosspoint;
a pin coupled to the actuator bar for displacement therewith;
a resilient contact arm secured to said carried bar adjacent said crosspoint and extending at an angle away from said carrier bar;
a stationary contact rod positioned to clear said contact arm upon angular deflections thereof;
means for longitudinally displacing said actuator bar to place said pin into engagement with said contact arm to deflect and urge same towards said carrier bar; and
means for longitudinally displacing said carrier bar to shift said deflected contact arm in the space between said stationary contact rod and said carrier bar.

9. A selector switch comprising:
at least one actuator bar mounted for longitudinal displacement;
at least one carrier bar mounted for longitudinal displacement in crossing relation to said actuator bar to establish at least one crosspoint;
a pin coupled to the actuator bar for displacement therewith;
a resilient contact arm secured to said carrier bar adjacent said crosspoint and extending at an angle away from said carrier bar;

a stationary contact rod positioned in the space between said carrier bar and said contact arm;
a first solenoid operatively coupled to said carrier bar for displacing same in a direction and for a distance so that said rod recedes from said space;
means for temporarily energizing said first solenoid;
spring means for returning said carrier bar after termination of energization of said first solenoid; and
a second solenoid for displacing said actuator bar, said pin upon energization of said first and second solenoids pivoting said contact arm towards said carrier so that its tip is closer to said carrier than said contact rod.

10. In a selector switch including a matrix having a plurality of displaceable actuator bars and a plurality of displaceable carrier bars in crossing relation to form at least one crosspoint, there being at least one switching element adjacent to the crosspoint and operable in response to coexisting displacements from normal positions of the bars of the crosspoint, the same switching element including:
an elongated resilient contact arm made from an electrically conductive material mounted on the carrier bar adjacent to the crosspoint, and extending away from said carrier bar at an angle to the bars crossing at the crosspoint;
a stationary contact member disposed in the angular space as defined by said carrier bar of said crosspoint and the direction of extension of said contact arm;
means coupled to the actuator bar and in actuating relation with respect to the contact arm for engaging the contact arm in response to displacement of the actuator bar defining the crosspoint and for bending the contact arm in directions toward the carrier bar suffiicent to permit insertion of said contact arm into the space between said stationary contact member and said carrier bar; and
means cooperating with said switching element for displacing said carrier bar and said bent contact arm to insert said contact arm into the space between said carrier bar and said stationary contact member.

References Cited by the Examiner

UNITED STATES PATENTS

1,200,885	10/1916	Schmid	200—1 X
1,567,532	12/1925	Marburg	179—27
2,741,669	4/1956	Barrett	179—27 X
3,102,931	9/1963	Simmons et al.	200—104 X

FOREIGN PATENTS

201,099	2/1956	Australia.

KATHLEEN H. CLAFFY, *Primary Examiner.*

J. R. SCOTT, *Assistant Examiner.*