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54 **Improved high-speed, multi-break electrical switch.**

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Description

Background of the Invention

Field of the Invention

The present invention relates to an improved high-speed, multi-break electrical switch. More specifically, the present invention constitutes a specific improvement of the switch claimed in document US—A—4,370,531. Reference is also made to documents US—A—4,342,978 and CA—A—1,129,460.

Brief Discussion of Prior Art

Document CA—A—1,129,460 discloses a high-voltage device which includes a fuse and a switch. The fuse is preferably a current-limiting fuse having a low continuous current rating which is normally shunted by the switch which has a high continuous current rating. When a fault current or other over-current occurs in the circuit to which the device is connected, the switch opens, commutating the current to the current-limiting fuse for limitation and interruption thereof. In document CA—A—1,129,460, the switch includes a pair of normally engaged contacts which are rapidly movable apart by the ignition of the power cartridge contained within a chamber defined by at least one of the contacts. The contacts move apart in a fixed line of direction forming a gap therebetween upon ignition of the power cartridge to open the switch and to effect current commutation to the current-limiting fuse. In preferred embodiments of document CA—A—1,129,460 the fuse coaxially surrounds the switch and both are contained in a common housing. This structure minimizes manufacturing costs, renders the overall device convenient to handle and manipulate, and minimizes the inductance of the overall device to ensure rapid commutation of the current from the switch to the fuse.

After the invention of document US—A—4,342,978 was made, the desirability of ensuring the rapid movement apart of the contacts upon ignition of the power cartridge was recognized, as was the fact that the ignition products of the power cartridge could well contaminate the gap which is created between the contacts. Such contamination of the gap may sufficiently lower the voltage of any arc forming in the gap between the contact, which in turn may slow up or prevent rapid commutation of current from the switch to the fuse. In recognition of these problems, the switch of document US—A—4,342,978 includes a piston mounted on one of the contacts which is movable away from the other contact which may be stationary. This piston defines a portion of the closed chamber which contains the power cartridge and is movable, as its contact moves, through an insulative sleeve against which it seals. The gap between the contacts is, accordingly, electrically insulated and any arc formed between the contacts is constricted between the piston and the sleeve. Moreover, the piston is so related to its contact and the sleeve that it ensures rapid movement of its contact away from the

stationary contact and isolates its contact from the ignition products of the power cartridge. In preferred embodiments, the piston and the sleeve are both made of an ablative, arc-extinguishing material. Thus, arc-extinguishing gas is generated by the piston and the sleeve during arc constriction. The constriction and the gas raise the arc voltage resulting in rapid commutation of the current from the switch to the fuse.

Document US—A—4,342,978 also contemplates that the contact mounting the piston is normally electrically connected to a terminal of the device. The terminal is connectable to one side of a circuit being protected, while the stationary contact is connectable to the other side of the circuit. The electrical connection between the movable contact and the terminal is claimed in that application as comprising a variety of sliding contacts.

The invention of document US—A—4,342,978 contemplates normally electrically interconnecting the switch contacts with a shearable or severable diaphragm-like member. Upon ignition of the power cartridge and movement apart of the switch contacts, the diaphragm is severed, torn, ripped or otherwise rendered discontinuous, thus breaking the normal electrical interconnection therebetween to open the switch. The use of a shearable diaphragm offers several advantages over sliding contact elements. First, in its normal state, the diaphragm is an integral, continuous member capable of carrying high currents. Sliding contact elements must be able to normally carry current across the interface therebetween when they are stationary and frictionally engaged, and to subsequently freely frictionally slide or move relative to each other. This latter property can result in a compromise in the first property. That is, because the normal frictional engagement between the elements must be such as to permit subsequent free relative movement of the elements, the current-carrying ability of the interface may be less than that of a solid or integral conductor. Second, when integral, the diaphragm positively prevents movement of the switch contacts between which it is connected. Sliding contact elements being only normally frictionally engaged cannot as positively prevent movement of the switch contacts they normally electrically interconnect. Third, substantial force is required to sever or tear the diaphragm. This permits the pressure of the ignited power cartridge to "build up" against the piston until the diaphragm is severed, thus ensuring rapid movement apart of the switch contacts. Sliding contact elements cannot ensure this rapid movement apart due, in great part, to the requirement, discussed above, that the elements be relatively movable.

Accordingly, the present invention specifically contemplates using such a shearable diaphragm or similar structure to both normally electrically interconnect the switch contacts and to normally electrically interconnect the one contact mounting the piston to the terminal. Both diaphragms

are severed or otherwise rendered discontinuous upon ignition of the power cartridge. More generally, the present invention contemplates a switch capable of opening more than the two gaps opened by the switch of document US—A—4,342,978. Each such gap is opened by severing a diaphragm or similar structure.

Document US—A—4,370,531 shows, in Figure 4, a switch cell between two different terminal cells and corresponds to the switch cell shown in device 12 of Figure 1 of the present application. This switch device includes two severable electrical connections and, when operated, two insulated gaps are formed in the electrical connection between the terminal cells.

However, where high fault currents are involved, switches with one or two gaps are less effective in interrupting the circuit being protected than is desirable. The present invention seeks, therefore, to provide a switch with more insulated gaps and of such a design that it can be readily fabricated and wherein the number of gaps can be increased to the desired number appropriate for any particular application.

According to the present invention, there is provided an electrical switch, comprising:

a switch cell of a first type and a switch cell of a second type, wherein

the first type of cell has

first conductive means, with a first bore therethrough between the ends thereof, and

first insulative means conformally located in and movable through and out of the first bore of said first conductive means, and wherein

the second type of cell has

second insulative means with a second bore therethrough between the ends thereof, the first and second bores having substantially the same cross-section, and

second conductive means conformally located in and movable through and out of the second bore:

housing means for mounting the cells end-to-end so that the first and second bores align to form a continuous passage;

a severable conductive member for electrically interconnecting the first and second conductive means;

force-applying means for simultaneously moving the first insulative means and the second conductive means in a given direction through the passage, so that the first insulative means moves both conformally out of its first bore, and, conformally into the second bore of such adjacent cell, and so that the second conductive means moves conformally out of its second bore,

wherein the movement of said first insulative means and said second conductive means severs said severable conductive member so that a gap is formed between the second conductive means and the first conductive means on the side of the second conductive means opposite to the given direction, the gap so formed being electrically insulated by the conformal reception

of the first insulative means in the second bore of the second insulative means, characterised in that:

there are X switch cells of said first type and Y switch cells of said second type where X and/or Y is or are greater than 1;

the first and second type cells are all mounted end-to-end in an alternating series so that the respective first and second bores align and all but the terminal cells of the series have, at both ends thereof, an adjacent cell of the other type;

there are electrical interconnections between all adjacent first and second conductive means; and such that operation of said force-applying means moves each first insulative means and each second conductive means conformally out of its own respective bore and, where there is an adjacent cell in the given direction, conformally into the bore of that adjacent cell, whereby electrical interconnections are broken and insulated gaps formed between adjacent first and second conductive means.

The present invention thus contemplates a "building block" approach to the construction of electrical switches. More specifically, the present invention recognizes that individual switch cells of two different types having specific characteristics may be alternated in a side-by-side series to produce a switch in which a multiplicity of insulated gaps are simultaneously opened upon ignition of a power cartridge. The fact that multiple insulated gaps are opened by the improved switch of the present invention means that after a very small amount of contact movement, numerous gaps — possibly with arcing therein — are formed to ensure rapid commutation of the current from the switch to the fuse.

In specific embodiments of the switch, the insulative members include an ablative, arc-extinguishing material.

Brief Description of the Drawing

Figure 1 is a side elevational, partially-sectioned view of a device incorporating an improved high-speed switch in accordance with US—A—4,370,531, the device also including a fuse to produce a high-voltage device, both of the latter being only generally depicted;

Figure 2 is a side elevational, sectioned partial view of a switch illustrating a "building block" approach to the construction of improved switches according to the present invention; and

Figure 3 is a specific embodiment of the switch depicted in Figure 2.

Detailed Description

Referring first to Figure 1, there is shown a high speed switch 10 in accordance with Figure 4 of US—A—4,370,531. The switch 10 may be used as a component of a high-voltage device, generally indicated at 12, which includes both the switch 10 and a parallel electrical path shown only schematically at 14. The path 14

may include a fuse or a fusible element 16, although other components are contemplated. The normally closed switch 10 has a high continuous-current carrying capability and shunts the path 14. The fuse 16 is preferably a current-limiting fuse, although non-current-limiting fuses are contemplated. Normally when the switch 10 is closed, little current passes through the path 14 or the fuse 16. As is well known, current-limiting fuses 16 have a low continuous-current carrying capability. The closed switch 10 eliminates the fuse 16 having to carry a substantial amount of current. When the switch 10 opens, current is commutated to the path 14 and to the fuse 16 for interruption thereof, as more fully explained in documents CA—A—1,123,460 and US—A—4,342,978.

The device 12 may include an outer insulative housing, generally designated 18, containing both the switch 10 and the path 14. An inner insulative housing 22 contains the various elements of the switch 10. In the event that the device 12 is intended to operate as a current-limiting or energy-limiting fuse, a volume 20 defined between the housings 18 and 22 may be filled with a fulgurite-forming arc-quenching medium, such as silica or quartz sand (not shown) to aid in the current-limiting action of the fuse 16. The housing 22 isolates the elements of the switch 10 from the medium. The general operation and construction of the device 12 is more specifically described in the above-noted documents CA—A—1,129,460 and US—A—4,342,978.

The switch 10 includes a first tubular member 24 fixed at one end to the housing 22. The conductive member 24 may protrude beyond the end of the outer housing 18 and may serve as a mount and a connection for the device 12 to one side of a high-voltage circuit (not shown) which the device 12 is intended to protect. The conductive member 24 defines both an interior bore 26 and a portion of an enclosed chamber 28 contiguous therewith. The bore 26 preferably, but not necessarily, has a circular cross-section. Normally located in the chamber 28 is a power cartridge 30 or the like which is selectively ignitable to pressurize the chamber 28. Ignition of the power cartridge 30 results in the generation of solid and gaseous ignition products, some of which are conductive. The power cartridge 30 may be selectively ignited by applying to input conductors thereof (not shown) an appropriate signal in response to the occurrence of a fault current or other over-current in the circuit to which the device 12 is connected. For further details of the power cartridge 30, reference should be made to the earlier noted documents CA—A—1,129,460 and US—A—4,342,978.

Normally conformally located within the bore 26 is an electrically insulative piston-like member 32, which may be similar to the trailer of a so-called trailer-liner interrupter. Preferably, the piston 32 is made of an ablative, arc-extinguishing material which evolves arc-extinguishing gas in response to the heat of an electrical arc. Prefer-

ably, the member 32 fills or nearly fills the bore 26 so that one end thereof is normally adjacent, and aids in defining, the chamber 28. In the orientation depicted in Figure 1, ignition of the power cartridge 30 pressurizes the chamber 28 and conformally moves the member 32 rightwardly in the bore 26.

To the right of the member 24, the central portion of the housing 22 defines a bore 34. In preferred embodiments, the insulative housing 22 is made of glass-reinforced epoxy and the bore 34 is lined with an electrically insulative sleeve or layer 36, preferably made of an ablative, arc-extinguishing material. The sleeve 36 defines an interior bore 38. Normally conformally located in the bore 38 is a conductive rod 40, the outer surface of which carries an insulative sleeve or layer 42. The rod 40 with the sleeve 42 thereon is conformally movable through and out of the bore 38. The bore 38 is substantially the same cross-section as and is aligned with the bore 26. Thus, the member 32 is both conformally movable through and out of the bore 26 and conformally movable into the bore 38.

The right end of the insulative housing 22 mounts a second tubular conductive member 44 which may be similar to the first member 24. A portion of the member 44 may protrude beyond the housing 18 for mounting the device 12 and for connecting it to the other side of the circuit protected by the device 12. The second conductive member 44 defines an interior bore 46 aligned and contiguous with the bore 38 which is lined with an insulative sleeve 48, itself defining an interior bore 50. The bore 50 preferably has a circular cross-section and, although it need not have the same diameter cross-section as the bores 38 and 26, is of a shape to permit conformal movement thereinto of the rod 40 with the insulative sleeve 42 thereon. If desired, the bores 26, 38 and 50 may all have the same cross-section.

Normally electrically interconnecting the first conductive member 24 and the rod 40 is a metallic member 52. The metallic member may take the form of a shearable, severable, tearable or breakable diaphragm or annular member having a general cup-shape, the lip of the cup being normally connected as by brazing, welding or the like to a first member 24 and the bowl of the cup being connected to the rod 40 by a connector 54, such as a rivet, stud or the like. The member 52 may take other forms such as one or more wires or conductive strips, a metal disc or a body of solder or the like. Rightward movement of the piston-like member 32 due to ignition of the power cartridge 30 causes the right edge of the piston 32 to bear against one side of the metallic member 52 while at the same time the left edge of the sleeve 36 bears against the metallic member 52 from the other side. Ultimately, the metallic member is sheared and the electrical interconnection between the first member 24 and the rod 40 is broken. To aid in this shearing action, the metallic member 52 may contain a weakened or pre-scored portion, as more fully described in the

above-noted document US—A—4,342,978. The connector 54 both attaches the metallic member 52 to the rod 40 and connects the piston 32 and the rod 40 to ensure conjoint movement thereof.

Normally electrically interconnecting the rod 40 and the second conductive member 44 is a metallic member 56 which may be the same as or similar to the metallic member 52. Upon rightward movement of the rod 40, the metallic member 56 is sheared by the action of the right edge of the insulative sleeve 42 and the left edge of the sleeve 48. Similar to the metallic member 52, the metallic member 56 may generally comprise a cup-shaped diaphragm or annulus, the lip or rim of which is connected as by welding, brazing or the like to the second member 44 and the bowl of which is attached by a connector 58 directly to the rod 40. As pointed out more fully in US—A—4,342,978, metallic members such as those shown at 52 and 56 may be adjacent a cutting edge or member (not shown) instead of or in addition to pre-weakening thereof to ensure that they are severed, as described above. The metallic member 56 may, of course, comprise functionally similar members such as wires, metal strips, metal discs, a body of solder or the like.

Assuming that both members 24 and 44 are connected to an electrical circuit, and whether or not the path 14 is used in conjunction with the switch 10, the elements of this switch 10 normally assume the position depicted in Figure 1. A normal current path through the switch 10 therefore includes, in order, the first member 24, the metallic member 52, the rod 40, the metallic member 56, and the second member 44. Should it be desired to open the switch 10, for example, because of the occurrence of a fault current or other over-current in the circuit to which the switch 10 is connected, the power cartridge 30 is ignited to pressurize the chamber 28. This moves both the piston 32 and the rod 40 with the insulative sleeve 42 thereon rightwardly. Rightward movement of the piston 32 severs the metallic member 52, and rightward movement of the rod 40 severs the metallic member 56, as described above. Further, the piston 32 conformally moves through and out of the bore 26 and conformally into the bore 38 while the rod 40 with the insulative sleeve 42 thereon moves through and out of the bore 38 and conformally into the bore 50.

The rightward movement of the rod 40 and the severance of the metallic members 52 and 56 opens the switch 10 at two locations and opens two gaps therein. The first gap is opened between the right end of the member 24 and the left end of the rod 40, which together may be viewed as a first contact pair 24, 40. The second gap is opened between the right end of the rod 40 and the left end of the member 44 acting as a second contact pair 40, 44. The first gap is electrically insulated by the conformal reception of the piston 32 in the sleeve 36. The second gap is electrically insulated by the conformal reception of the sleeve 42 in the sleeve 48.

If the circuit to which the switch 10 is connected

is, as contemplated, at a sufficiently high voltage, arcing may occur in the two gaps. Specifically, arcing may occur in the first gap between the member 24 — probably at or in the vicinity of the lip of the metallic member 52 connected to the member 24 — and the rod — probably at or in the vicinity of the bowl of the member 52 carried by the rod 40. Because the piston 32 has conformally entered the bore 38, the first arc between the member 24 and the rod 40 is constricted between the piston 32 and the sleeve 36. This constriction is accompanied by the evolution of arc-extinguishing gas should the piston 32 or the sleeve 36 include an ablative arc-extinguishing material. Both the constriction and the arc-extinguishing gas tend to raise the voltage of or extinguish the arc, either or both of which effect current commutation to the path 14. Moreover, the conformal reception of the piston 32 in the bores 26 and 38 prevents or hinders the conductive ignition products of the power cartridge 30 from reaching the right end of the member 24 or the left end of the rod 40, thus eliminating substances which could encourage the arc to persist or lower its voltage.

Arcing may also occur in the second gap. Specifically, such arcing may occur between the left end of the member 44 — or the lip of the metallic member 56 remaining thereon — and the right end of the rod 40 — or the bowl of the member 56 carried thereby. This second arc is constricted between the insulative sleeves 42 and 48 because of conformal reception of the rod 40 and the sleeve 42 thereon in the bore 50. Thus, the second arc is constricted and subjected to the action of arc-extinguishing gas if the sleeves 42 and 48 are made of an ablative, arc-extinguishing material. Further, the second gap has excluded therefrom any ignition products of the power cartridge 30 which manage to infiltrate into and beyond the first gap.

In the switch 10 of Figure 1, the members 24 and 44 are similar and, indeed, may be used interchangeably at either end thereof. Because the member 44 is lined with the sleeve 48, the diameter of the bore 46 is slightly less than the diameter of the bore 26. Thus, the diameters of the members 52 and 56 are slightly different as depicted in Figure 1. This difference in the diameters of the bores 26 and 50 leads to the diameter of the rod 40 with the insulative sleeve 42 thereon being slightly smaller than the diameter of the bore 38 in order to facilitate movement of the rod 40 with the sleeve 42 thereon conformally into the bore 50. As noted previously, the diameter of the bore 38 must be sufficiently large to accommodate conformal movement thereof of the piston 32. If similarity of the members 24 and 44 is not a primary concern, the diameters of the bores 26, 38 and 50 may all be the same, which requires that the bore 46 of the member 44 be initially somewhat larger than the diameter of the bore 26. In this event, the diameters of the piston 32 and the rod 40 with the sleeve 42 thereon are the same.

It should be noted that, unlike the switches of documents CA—A—1,129,460 and US—A—

4,342,978 the present switch 10 opens two electrically insulated gaps. As previously discussed, the switch of CA—A—1,129,460 opens a single electrically uninsulated gap, while the switch of US—A—4,342,978 opens a single electrically insulated gap. Further, the switch according to US—A—4,370,531 contemplates normally electrically interconnecting each of two contact pairs 24, 40 and 40, 44 with the metallic members 52 and 56.

Turning now to Figure 2, there is shown an improved switch 10 constructed along a "building block" approach according to the present invention. This switch can rapidly produce practically any desired larger number of electrically insulated gaps so as rapidly to open a high-voltage current path.

The improved switch 10 of Figure 2 includes two types of switch cells 64 and 66. A specific form of the first type of switch cell 64 comprises a first tubular conductive member 67 defining a bore 68 therethrough between the ends thereof. The bore 68 contains or is lined with an insulative layer or sleeve 69 defining a bore 70. Normally conformally positioned within the bore 70 is an insulative member 71 which is conformally movable through and out of the bore 70. In a more general form, the layer 69 is not used, and the first type of switch cell 64 may include only the conductive member 67 with the bore 68 and the insulative member 71 in and conformally movable through and out of the bore 68. Differences in operation between the specific and general first type of cell 64 are explained below. Whichever first cell 64 is used, the bore 70 (68 in the general form) and the insulative member 71 preferably have circular cross-sections, but other cross-sections are contemplated. Moreover, the inside diameter of the bore 70 — or of the bore 68 if the layer 69 is not used — while preferably substantially equal to the outside diameter of the insulative member 71, may be slightly larger than the diameter of the member 71. Preferably, the member 71 and the layer 69 (where used) comprise or contain an ablative, arc-extinguishing material, such as Nylon®, Delrin®, polyethylene, melamine, polytetrafluoroethylene, horn fiber or the like.

A specific form of the second type of switch cell 66 comprises a tubular insulative member 72 defining a bore 73 therethrough between the ends thereof. Conformally contained within the bore 73 and conformally movable through and out of the bore 73 is a conductive member 74 covered with an insulative layer or sleeve 75. In a more general form, the layer 75 is not used, and the second type of switch cell 66 may include only the insulative member 72 with the bore 73 and the conductive member 74 conformally located therein and conformally movable therethrough. Whichever second cell 66 is used, the bore 73 and the conductive member 74 with the layer 75 thereon (or the member 74 alone if the layer 75 is not present) preferably have circular cross-sections, other cross-sections being contemplated. Also, the

inside diameter of the bore 73, while preferably substantially equal to the outside diameter of the layer 75 — or of the member 74, if the layer 75 is not used — may be slightly larger than this diameter. Preferably, the member 72 and the layer 75 (where used) comprise or contain an ablative arc-extinguishing material.

In a specific form of the switch 10, an alternating series . . . 64, 66, 64, 66, 64, 66 . . . etc. of the first and second cells 64 and 66 is formed. Specifically, a housing 22', which may be similar to the housing 22 shown in Figure 1, maintains each cell 64, 66 in an end-to-end relationship to its adjacent cell or cells 66 or 64 so that the bores 70 and 73 are aligned. The bores 70 and 73 have cross-sections of the same size and configuration. Accordingly, the bore 70 and 73 of the alternating, end-to-end series of cells 64 and 66 form a continuous passage . . . 70, 73, 70, 73, 70, 73 . . . etc. Also, each insulative member 71 is conformally movable into the bore 73 of an adjacent second cell 66, while each conductive member 74 with its layer 75 is conformally movable into the bore 70 of an adjacent first cell 64. Each cell 64 and 66 is adjacent at both of its ends to a cell 66 and 64 of the opposite type, except those cells at the termini of the series. In Figure 2, there terminal cells are shown as one cell 64 (at the left) of the first type and one cell 66 (at the right) of the second type. It should be clear that the series may also terminate with a first cell 64 at both ends, with a second cell 66 at both ends, or with a second cell 66 at the left and a first cell 64 at the right. The number X of first cells 64 or the number Y of second cells 66 is greater than 1. As a consequence, preferred specific forms of the switch 10 shown in Figure 2 include the following series of cells 64 and 66: 64, 66, 64; 66, 64, 66; 64, 66, 64, 66; 66, 64, 66, 64; 64, 66, 64, 66, 64; etc. The series will always include either the same number of first and second cells 64 and 66 (if the series has an even number of cells), or one more of one type than the other (if the series has an odd number of cells).

Metallic members 76 normally electrically interconnect the conductive members 67 and 74 of adjacent cells 64 and 66. This means that the conductive member 67 of all but terminal first cells 64 are normally electrically interconnected to the conductive member 74 of both adjacent second cells 66, and that the conductive member 74 of all but terminal second cells 66 are normally electrically interconnected to the conductive member 67 of both adjacent first cells 64. The conductive members 67 and 74 of terminal cells are electrically interconnected to the conductive members 74 and 67 of the only cell of the opposite type 66 and 64 which is adjacent thereto. The metallic members 76 are the same as or similar to the severable or shearable metallic members or diaphragms 52 and 56 shown in Figure 1.

Application of a force to either end of the switch 10 conjointly moves the insulative member 71 of each cell 64 and the conductive member 74 with the layer 75 of each cell 66 in the direction of application. To this end, adjacent members 71

and 74 and the member 76 therebetween may be held together by connectors which are not shown in Figure 2, but may be similar to the connectors 54 and 58 of Figure 1 which represents the switch of US—A—4,370,531. In Figure 2, if the force is applied rightwardly to the insulative member 71 of the left-hand terminal cell 64, all of the members 71 and 74 move rightwardly. Further, each member 71 and 74 — except that of the right-hand adjacent cell 66 — moves conformally out of its respective bore 70 or 73 and conformally into the bore 73 or 70 of its right-hand adjacent cell 66 or 64. The member 74 of the right-hand terminal cell 66 merely moves out of its bore 73. A similar, but mirror-image, result is achieved if a leftwardly directed force is applied to the member 74 of the right-hand terminal cell 66, except that the member 71 of the left-hand terminal cell 64 merely moves out of its bore 70. The force applying means is preferably similar to the power cartridge 30 described above with reference to Figure 1, as more fully explained below with reference to Figure 3.

For purposes of describing the specific form of switch shown in Figure 2, it is assumed that conductive member 67 of the left-hand terminal cell 64 and the conductive member 74 of the right-hand terminal cell 66 are continuously, electrically connected to an energized electrical circuit. Further, the members 67 and 74 may also be electrically connected to a parallel path, similar to the path 14 of Figure 1.

Assuming the application of the rightwardly directed force, in a general sense, the switch 10 of Figure 2 operates much like the switch 10 of Figure 1 in that movement of the insulative member 71 of the left-hand terminal cell 64 moves all other insulative members 71 and all other conductive members rightwardly. This movement simultaneously severs all of the metallic members 76 producing an insulated gap at the point of severance of each such member 76. Specifically, as each metallic member 76 is rendered discontinuous, as described with reference to Figure 1, the conductive members 74 conformally move into the bore 70 of the rightwardly adjacent first cell 64. This movement opens a first gap between the left end of each member 74 and the right end of the leftwardly adjacent member 67. Each first gap is insulated by the conformal engagement between the leftwardly adjacent insulative member 71 and the bore 73 of the insulative member 72 being vacated by the moving member 74. A second gap is also opened between the right end of each member 74 and the left end of the rightwardly adjacent member 67. Each second gap is insulated by the conformal engagement of the layer 75 on each member 74 and the bore 73 of the rightwardly adjacent insulative member 72 into which the member 74 is moving.

The insulation of the gaps by the member 71 and the layers 69 and 75 achieves the same ends as achieved by the piston 32 and the sleeves 36, 42 and 48 of Figure 1 relative to arc constriction

and extinguishment and to isolation of the gaps from the ignition products of the power cartridge 30. The voltages of any arcs forming in the gaps are additive in effect. Thus, the effect of quickly opening multiple gaps with multiple arcs therein is the equivalent of opening a single long gap with a single long arc therein. However, the multiple gaps are opened simultaneously in a much shorter time than the long gap can be opened because of the short distance through which the members 71 and 74 are moved. Thus, the switch of Figure 2 is quite fast-acting and may achieve rapid, positive commutation of current to a parallel path.

If desired, a stop or brake (not shown) may be used to limit the movement of the members 71 and 74. Specifically, it may be desirable to stop the train of members 71 and 74 when each member 71 and 74 has moved part way through the adjacent bore 73 and 68.

The switch 10 may also include an alternating series of the more general forms which may be taken by the cells 64 and 66, as discussed earlier. If both types of more general cell 64 and 66 are used, only the first insulated gap is formed. Specifically, neither layer 67 or 75 is present. Thus, the insulative members 71 normally conformally reside in the bores 68 and the conductive members 74 are in direct conformal engagement with the bores 73. The bores 68 and 73 have, in this event, similar cross-sections and are aligned, for example, by the housing 22'. Rightward movement of the train of members 71 and 74, as described above, severs the metallic members 76, but insulated gaps are formed by the conformal engagement between the members 71 and 72 only between the left end of each member 74 and the right end of the leftwardly adjacent member 67. No gap is formed between the right end of the member 74 and the left end of the rightwardly adjacent member 67, between which there will be sliding contact or only a small separation. As should be obvious, alternate metallic members 76 — those shown in Figure 2 as interconnecting the right end of the members 74 to the left end of the rightwardly adjacent members 67 — may be omitted or some other form of normal interconnection, such as a small overlap, may be substituted.

If the specific cells 64 or 66 of either type are used, second insulated gaps will be formed. Specifically, if the more general first type of cell 64 is used with the more specific second type of cell 66, second insulated gaps are formed by the conformal engagement between the layer 75 and the bore 68 of the rightwardly adjacent member 67 into which each member 74 moves. In this event, the bores 68 and 73 have similar cross-sections. If the specific first cells 64 are used with the more general second cells 66, second insulated gaps are formed by the conformal engagement between the members 74 (without the layers 75) and the bore 70 of the rightwardly adjacent layers 69. In this event, the bores 70 and 73 have similar cross-sections. General and

specific types of cells 64 and 66 may be combined and permitted to open second gaps at preselected locations of the switch 10.

Turning now to Figure 3, there is shown a specific embodiment of the switch 10 in accordance with the building block approach generally illustrated in Figure 2. Figure 3 illustrates, specifically, a way in which to move the train of members 71 and 74 and in which the members 67 or 74 may be continuously connected to a circuit.

As can be seen in Figure 3, the switch 10 includes two cells of the second type 66 between which is a single cell of the first type 64. Unlike the generalized switch in Figure 2, the switch 10 of Figure 3 terminates at either end with structure that deviates somewhat from the specific form of the first and second cells 64 and 66. Specifically, the cell at the right of the switch 10 in Figure 3 — which is like that shown at the right of Figure 1 and bears the same reference numerals — is similar to the first type of cell 64, except that it normally contains no insulative member 71 therein. This permits the leftwardly adjacent conductive member 74 with the layer 75 thereon to move into the bore 50 of the sleeve 48. Similarly, the cell at the left of the switch 10 in Figure 3 contains only the piston 32 (which is similar to the member 71) within the bore 26 of the tubular conductive member 24 (which is similar to the member 67) like the structure depicted at the left in Figure 1. This structure is representative of the first type of cell 64 in its general form, that is, the insulative layer 69 is not present. Thus, the switch 10 of Figure 3 includes one first cell 64 in its general form and one first cell 64 in its specific form alternated with two second cells 66 in the specific form. By the same token, then, the switches of Figure 1 may be said to constitute a first cell 64 in its general form (the members 24 and 32) and a second cell 66 in its specific form (the members 36, 40 and 42). Similar to the structure shown in Figure 1, the member 24 houses the power cartridge 30 in the enclosed chamber 28. Ignition of the power cartridge 30 exerts a rightwardly directed force on the piston 32. Rightward movement of the piston 32 moves the train of members 71 and 74 to the right. Any number of first and second cells 64 and 66 may be alternated and the ends of the switch 10 may take any convenient configuration. Since the switch 10 of Figure 3 contains four metallic members 76 and since the specific forms of the cells 64 and 66 are utilized, four gaps are opened during the operation thereof. The opening of four gaps creates a high arc voltage between the conductive members 24 and 44 which will effect the rapid commutation of current in the switch 10 to the fuse 14 if such is used with very little movement of the members 71 and 74.

Claims

1. An electrical switch, comprising:
a switch cell of a first type (64) and a switch cell of a second type (66), wherein

the first type of cell (64) has
first conductive means (67), with a first bore (68) therethrough between the ends thereof, and first insulative means (71) conformally located in and movable through and out of the first bore (68) of said first conductive means (67), and wherein

the second type of cell (66) has
second insulative means (72) with a second bore (73) therethrough between the ends thereof, the first (68) and second (73) bores having substantially the same cross-section, and

second conductive means (74) conformally located in and movable through and out of the second bore (73):

housing means (22') for mounting the cells end-to-end so that the first and second bores align to form a continuous passage;

a severable conductive member (76) for electrically interconnecting the first and second conductive means;

force-applying means (30) for simultaneously moving the first insulative means (71) and the second conductive means (72) in a given direction through the passage, so that the first insulative means (71) moves both conformally out of its first bore (68), and, conformally into the second bore (73) of such adjacent cell, and so that the second conductive means moves conformally out of its second bore,

wherein the movement of said first insulative means and said second conductive means severs said severable conductive member so that a gap is formed between the second conductive means and the first conductive means on the side of the second conductive means opposite to the given direction, the gap so formed being electrically insulated by the conformal reception of the first insulative means in the second bore of the second insulative means,

characterized in that:

there are X switch cells of said first type (64) and Y switch cells of said second type (66) where X and/or Y is or are greater than 1;

the first (64) and second (66) type cells are all mounted end-to-end in an alternating series so that the respective first (68) and second (73) bores align and all but the terminal cells of the series have, at both ends thereof an adjacent cell of the other type;

there are electrical interconnections between all adjacent first (67) and second (74) conductive means; and such that operation of said force-applying means (30) moves each first insulative means (71) and each second conductive means (74) conformally out of its own respective bore and, where there is an adjacent cell in the given direction, conformally into the bore of that adjacent cell, whereby electrical interconnections are broken and insulated gaps formed between adjacent first (67) and second (74) conductive means.

2. A switch as claimed in claim 1 wherein said first conductive means (67) further comprises an electrically insulating layer (69) lining the first bore (68) therethrough.

3. A switch as claimed in claim 1 wherein said second conductive means (74) further comprises an electrically insulating layer (75) covering the exterior surface thereof.

4. A switch as claimed in claim 1, being further characterized by:

the cell on the end of the switch opposite to the given direction being a cell of the first type (64), wherein said first conductive means (67) and said first insulative means (71) of the cell on the end of the switch opposite to the given direction define an enclosed chamber (28), and wherein said force-applying means (30) further comprises ignitable means located within the chamber, ignition of the ignitable means pressurizing the chamber to rapidly move said first insulative means (32) of the cell on the end of the switch opposite to the given direction into the second bore (73) of the adjacent cell of the second type (66).

5. A device including a switch as claimed in claim 1, and being further characterized by:

an electrical component (16), and

means for electrically connecting said electrical component in parallel with said first and second conductive means of the alternating series of cells, wherein the forming of said insulated gaps by movement of said first insulative means (71) and said second conductive means (74) effects commutation of any current in said first (67) and second (74) conductive means of the alternating series of cells (64, 66) to said electrical component (14).

6. A device as claimed in claim 5 wherein said electrical component comprises a fusible element (16).

7. A switch as claimed in claim 1 further comprising:

a first terminal cell on one end of the alternating arrangement of said first (64) and second (66) types of cells, said first terminal cell being adapted to transmit the force imparted by said force means to said movable conductive means (74) and said movable insulative means (71); and

a second terminal cell (44) positioned at the opposite end of the alternating arrangement of said first and second types of cells from said first terminal cell (24), said second terminal cell being adapted to receive the axial movement of said movable conductive means and said movable insulative means.

8. An electrical switch as claimed in claim 7 wherein said first terminal cell is a cell of said first type (64).

Patentansprüche

1. Elektrischer Schalter, enthaltend:

— eine Schaltzelle erster Art (64) und eine Schaltzelle zweiter Art (66), wobei die Schaltzelle erster Art (64) ein erstes leitendes Mittel (67) mit einer ersten von Ende zu Ende durchgehenden Bohrung (68) und ein erstes isolierendes Mittel (71) aufweist, das konform in der ersten Bohrung (68) des ersten leitenden Mittels (67) angeordnet ist und durch diese und aus dieser bewegbar ist,

und wobei die Schaltzelle zweiter Art (66) ein zweites isolierendes Mittel (72) mit einer zweiten von Ende zu Ende durchgehenden Bohrung (73) aufweist, wobei die erste (68) und die zweite (73) Bohrung im wesentlichen den gleichen Querschnitt aufweisen, und wobei ein zweites leitendes Mittel (74) konform in der zweiten Bohrung (73) angeordnet und durch diese und aus dieser bewegbar ist:

— Gehäusemittel (22') zur Aufnahme der Zellen in Ende zu Ende Anordnung, so dass die erste und die zweite Bohrung zur Bildung eines fortlaufenden Durchganges ausgerichtet sind;

— ein abschaltbares leitendes Element (76) zum elektrischen Verbinden des ersten und des zweiten leitenden Mittels;

— Kraftmittel (30) zum gleichzeitigen Bewegen des ersten isolierenden Mittels (71) und des zweiten leitenden Mittels (72) in eine gegebene Richtung durch den Durchgang, so dass das erste isolierende Mittel (71) sowohl konform aus seiner ersten Bohrung (68) als auch konform in die zweite Bohrung (73) einer solchen benachbarten Zelle bewegt wird, sodass das zweite leitende Mittel konform aus seiner zweiten Bohrung bewegt wird, wobei die Bewegung des ersten isolierenden Mittels und des zweiten leitenden Mittels das abschaltbare leitende Element abtrennen, sodass ein Spalt zwischen dem zweiten leitenden Mittel und dem ersten leitenden Mittel auf der Seite des zweiten leitenden Mittels entgegengesetzt zur gegebenen Richtung gebildet wird, der so gebildete Spalt ist durch die konforme Aufnahme des ersten isolierenden Mittels in der zweiten Bohrung des zweiten isolierenden Mittels elektrisch isoliert, dadurch gekennzeichnet, dass:

— X Schaltzellen erster Art (64) und Y Schaltzellen zweiter Art (66) vorhanden sind, wobei X und/oder Y grösser als 1 sind;

— die Zellen erster Art (64) und zweiter Art (66) stets Ende an Ende in alternierender Reihe angeordnet sind, so dass die entsprechenden ersten (68) und zweiten (73) Bohrungen fluchten und mit Ausnahme der Endzellen der Serie alle Zellen an beiden Enden jeweils eine angrenzende Zelle der andern Art aufweisen;

— es bestehen elektrische Verbindungen zwischen allen benachbarten ersten (67) und zweiten (74) leitenden Mitteln; das Ganze derart, dass die Betätigung der Kraftmittel (30) jedes erste isolierende Mittel (71) und jedes zweite leitende Mittel (74) konform aus seiner entsprechenden eigenen Bohrung herausbewegt und, sofern eine benachbarte Zelle in der gegebenen Richtung vorhanden ist, konform in die Bohrung der entsprechenden benachbarten Zelle einführt, wobei elektrische Verbindungen unterbrochen werden und isolierende Spalte zwischen benachbarten ersten (67) und zweiten (74) leitenden Mitteln gebildet werden.

2. Schalter nach Anspruch 1, worin das erste leitende Mittel (67) weiter eine elektrisch isolierende Schicht (69) aufweist, welche die erste Bohrung (68) vollständig auskleidet.

3. Schalter nach Anspruch 1, worin das zweite

leitende Mittel (74) weiter eine elektrische isolierende Schicht (57) aufweist, welche seine Aussenfläche überdeckt.

4. Schalter nach Anspruch 1, weiter gekennzeichnet dadurch, dass die Zelle am Ende des Schalters, welche der gegebenen Richtung abgewandt ist, eine Zelle erster Art (64) ist, wobei das erste leitende Mittel (67) und das erste isolierende Mittel (71) der Zelle am Ende des Schalters entgegengesetzt zur gegebenen Richtung eine geschlossene Kammer (28) definieren, und wobei die Kraftmittel (30) weiter in der Kammer angeordnete entzündbare Mittel enthalten, wobei eine Entzündung der entzündbaren Mittel die Kammer unter Druck setzen, um das erste isolierende Mittel (32) der Zelle am Ende des Schalters entgegengesetzt der gegebenen Richtung schnell in die zweite Bohrung (73) der angrenzenden Zelle zweiter Art (66) zu bewegen.

5. Vorrichtung mit einem Schalter nach Anspruch 1, weiter gekennzeichnet durch:

- eine elektrische Komponente (16), und
- ein Mittel zur elektrischen Verbindung der elektrischen Komponente parallel mit den ersten und den zweiten leitenden Mitteln der alternierenden Serie der Zellen, wobei die Bildung der isolierenden Spalten durch Bewegung der ersten isolierenden Mittel (71) und der zweiten leitenden Mittel (74) eine Kommunikation eines Stromes in dem ersten (67) und dem zweiten (74) leitenden Mittel der alternierenden Serie der Zellen (64, 66) mit der elektrischen Komponente (14) bewirkt.

6. Vorrichtung nach Anspruch 5, worin die elektrische Komponente ein schmelzbares Element (16) enthält.

7. Schalter nach Anspruch 1 weiter aufweisend:

- eine erste Endzelle an einem Ende der alternierenden Anordnung der Zellen erster Art (64) und der zweiten Art (66), wobei die erste Endzelle so ausgebildet ist, dass sie die von den Kraftmitteln erzeugte Kraft auf das bewegbare leitende Mittel (74) und das bewegbare isolierende Mittel (71) überträgt;
- eine zweite Endzelle (44), die an dem der ersten Endzelle (24) abgewandten Ende der alternierenden Anordnung der Zellen erster Art und zweiter Art angeordnet ist, wobei die zweite Endzelle zur Aufnahme der axialen Bewegung des bewegbaren leitenden Mittels und das bewegbaren isolierenden Mittels ausgebildet ist.

8. Schalter nach Anspruch 7, worin die erste Endzelle eine Zelle erster Art (64) ist.

Revendications

1. Interrupteur électrique, comprenant:
 - une cellule d'interrupteur d'un premier type (64) et une cellule d'interrupteur d'un second type (66),
 - le premier type de cellule (64) présentant un premier moyen conducteur (67) que traverse, entre ses extrémités un premier alésage (68) et

un premier moyen isolant (71) disposé dans le premier alésage (68) du premier moyen conducteur (67) en épousant la forme et pouvant se déplacer à travers ce premier alésage (68) et hors de celui-ci, et

le second type de cellule (66) présentant un second moyen isolant (72) que traverse, entre ses extrémités, un second alésage (73), les premier (68) et second (73) alésages ayant sensiblement la même section transversale, et

un second moyen conducteur (74) disposé dans le second alésage (73) en épousant la forme et pouvant se déplacer à travers ce second alésage (73) et hors de celui-ci,

un moyen de logement (22') servant à monter bout à bout les cellules de façon que les premier et second alésages d'alignent de manière à former un passage continu,

une pièce conductrice séparable (76) destinée à relier électriquement entre eux les premier et second moyens conducteurs,

un moyen d'application de force (30) destiné à déplacer simultanément le premier moyen isolant (71) et le second moyen conducteur (72) suivant une direction donnée à travers le passage, de sorte que le premier moyen isolant (71) se déplace à la fois hors de son premier alésage (68) en épousant la forme et jusque dans le second alésage (73) de la cellule adjacente en épousant la forme, et de sorte que le second moyen conducteur se déplace hors de son second alésage en épousant la forme,

le déplacement dudit premier moyen isolant et dudit second moyen conducteur sectionnant ladite pièce conductrice séparable de façon qu'il se forme un intervalle entre le second moyen conducteur et le premier moyen conducteur sur le côté de ce second moyen conducteur situé à l'opposé de la direction donnée, l'intervalle ainsi formé étant électriquement isolé par le logement, avec conformité de formes, du premier moyen isolant dans le second alésage du second moyen isolant,

caractérisé en ce que:

il existe X cellules d'interrupteur dudit premier type (64) et Y cellules d'interrupteur dudit second type (66), X et/ou Y étant supérieur(s) à 1, les cellules des premier (64) et second (66) types sont toutes montées bout à bout suivant une série alternée de façon que les premier (68) et second (73) alésages respectifs s'alignent et que toutes les cellules de la série à l'exception des cellules d'extrémité présentent, à l'une et l'autre de leurs extrémités, une cellule adjacente de l'autre type,

il existe des connexions électriques mutuelles entre tous les premiers (67) et seconds (74) moyens conducteurs adjacents,

de façon manoeuvre du moyen d'application de force (30) déplace chaque premier moyen isolant (71) et chaque second moyen conducteur (74) hors de son propre alésage respectif en épousant la forme et, lorsqu'il existe une cellule adjacente dans la direction donnée, jusque dans l'alésage de cette cellule adjacente en épou-

sant la forme, de sorte que les liaisons électriques mutuelles sont rompues et que des intervalles à isolation se forment entre les premiers (67) et seconds (74) moyens conducteurs adjacents.

2. Interrupteur tel que revendiqué dans la revendication 1, dans lequel ledit premier moyen conducteur (67) comprend en outre une couche électriquement isolante (69) doublant le premier alésage (68) qui le traverse.

3. Interrupteur tel que revendiqué dans la revendication 1, dans lequel ledit second moyen conducteur (74) comprend en outre une couche électriquement isolante (74) qui en couvre la surface extérieure.

4. Interrupteur tel que revendiqué dans la revendication 1, caractérisé en outre par le fait que la cellule disposée à l'extrémité de l'interrupteur qui est située à l'opposé de la direction donnée est une cellule du premier type (64), ledit premier moyen conducteur (67) et ledit premier moyen isolant (71) de la cellule disposée à l'extrémité de l'interrupteur qui est située à l'opposé de la direction donnée délimitent une chambre fermée (28), tandis que ledit moyen d'application de force (30) comprend en outre des moyens allumables disposés dans la chambre, l'allumage de ces moyens allumables mettant la chambre sous pression de façon à déplacer rapidement ledit premier moyen isolant (32) de la cellule disposée à l'extrémité de l'interrupteur située à l'opposé de la direction donnée, jusque dans le second alésage (73) de la cellule adjacente du second type (66).

5. Dispositif comprenant un interrupteur tel que revendiqué dans la revendication 1, et caractérisé

en outre par un composant électrique (16) et par des moyens permettant de relier électriquement ledit composant électrique en parallèle auxdits premier et second moyens conducteurs des séries alternées de cellules, la formation desdits intervalles à isolation par déplacement dudit premier moyen isolant (71) et dudit second moyen conducteur (74) réalisant un passage, vers ledit composant électrique (14), de tout courant passant dans lesdits premier (67) et second (74) moyens conducteurs de la série alternée de cellules (64, 66).

6. Dispositif tel que revendiqué dans la revendication 5, dans lequel ledit composant électrique est constitué par un élément fusible (16).

7. Interrupteur tel que revendiqué dans la revendication 1, comprenant en outre:

une première cellule d'extrémité disposée à une extrémité de l'agencement alterné desdits premier (64) et second (66) types de cellules, ladite première cellule d'extrémité étant destinée à transmettre la force impartie par ledit moyen d'application de force audit moyen conducteur mobile (74) et audit moyen isolant mobile (71), et une seconde cellule d'extrémité (44) disposée à l'extrémité opposée de l'agencement alterné desdits premier et second types de cellule par rapport à ladite première cellule d'extrémité (24), cette seconde cellule d'extrémité étant destinée à recevoir le déplacement axial dudit moyen conducteur mobile et dudit moyen isolant mobile.

8. Interrupteur tel que revendiqué dans la revendication 7, dans lequel ladite première cellule d'extrémité est une cellule dudit premier type (64).

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FIG. 1



