Aug. 5, 1958 H. W. GRAYBILL 2,846,529

HIGH CURRENT SWITCH

Filed April 5, 1954 2 Sheets-Sheet 1

FIG. 1

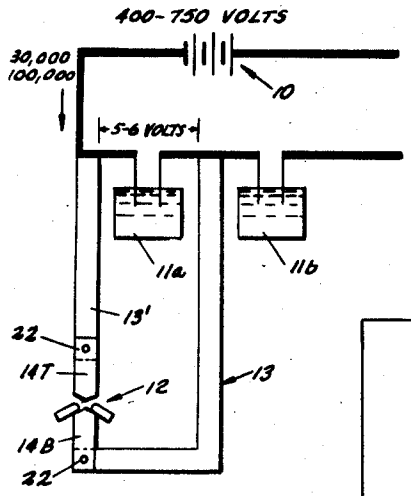
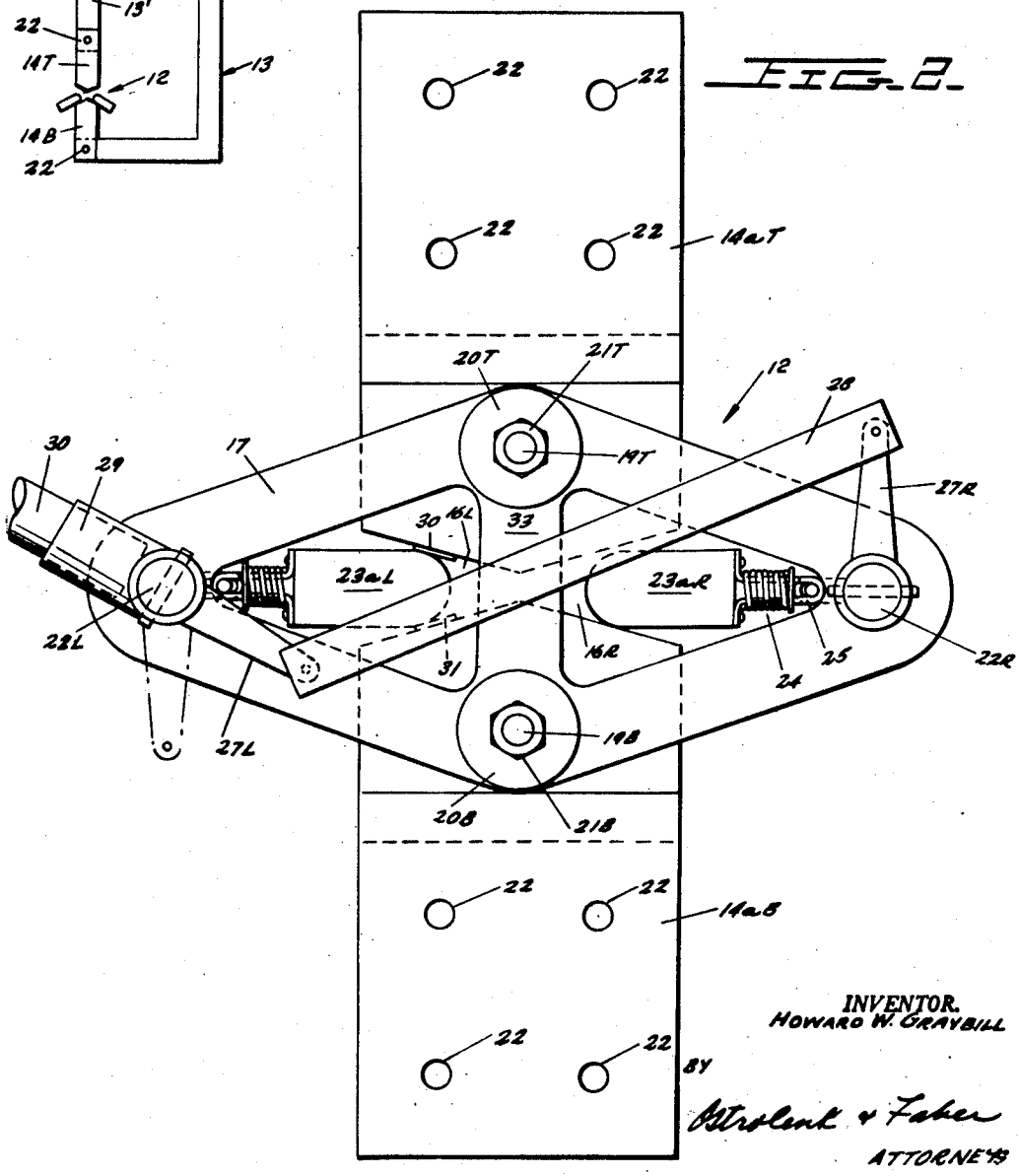


FIG. 2



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Aug. 5, 1958 H. W. GRAYBILL 2,846,529

HIGH CURRENT SWITCH

Filed April 5, 1954 2 Sheets-Sheet 2

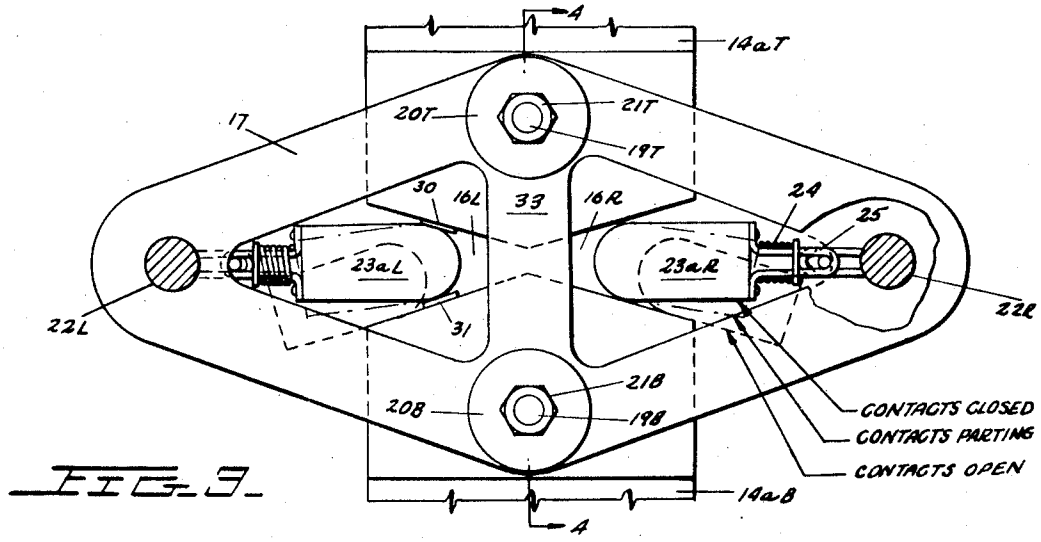

FIG. 3.

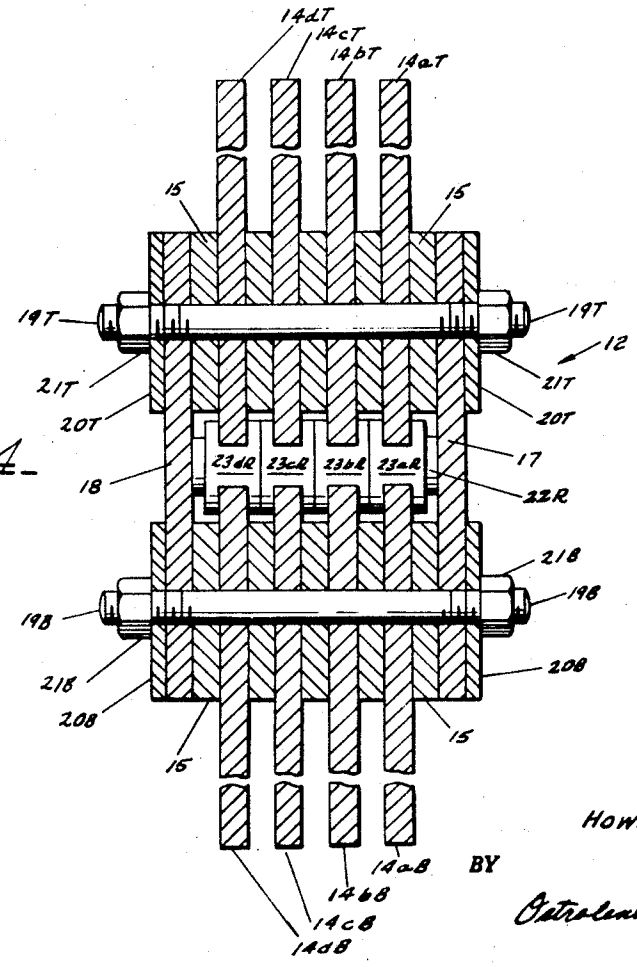

FIG. 4.

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HIGH CURRENT SWITCH

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Application April 5, 1954, Serial No. 420,976

5 Claims. (Cl. 200—16)

My invention relates to high current switch and is more particularly directed to a novel switch structure having a pair of bridging contact members which are particularly adaptable for bridging terminal bars which are in close proximity to each other.

The novel switch of my invention is particularly applicable for low voltage and high current rating.

One particular example of the application of this switch is in circuitry involving electrolytic cells such as aluminum pots or sodium cells. In these cases, the individual pots or cells operate at a relatively high current, for example from 30,000 to 100,000 amperes and with relatively low voltage of between 5 and 6 volts.

A plurality of cells are usually connected in series to form a pot-line which operates the voltage between 400 and 750 volts and the total pot-line current passes through each cell.

When one of the cells or pots is to be removed from service for maintenance or repair, it is necessary to short-circuit this unit.

The prior art arrangement used in the aluminum industry to shortcircuit the cells is to use copper wedges as switches, as shown in Figure 1 in my copending application Serial No. 357,021, filed May 25, 1953, which matured to Patent No. 2,766,335 on October 9, 1956.

The pot-line bus is made up of a plurality of sections, each of which consists of between 8 and 10 bars of aluminum or copper. These bars arranged with a wedge-shaped gap which is so arranged that the gap in the bus is in parallel with the cell. The normal current flow is, therefore, through the cell or pot-line.

To shortcircuit the cell or pot, a copper wedge is driven into the wedge shaped gap in the bus and if the shortcircuit is to be maintained for any appreciable period of time, the heavy copper plates are bolted to either side of the bus. As described in my copending application Serial No. 357,021, filed May 25, 1953, this procedure is both time consuming, expensive and dangerous.

The switching structure shown in my copending application Serial No. 357,021, filed May 25, 1953, is particularly adaptable for a plurality of spaced parallel buses wherein the wedge shaped gap runs the width of the rectangular copper conductor and the moving or bridging contacts for the gap can be positioned between the busbars. However, the embodiment shown in this copending application can not be used where there are a number of terminal bars which are spaced apart a distance no greater than the thickness of the bars.

The switch of my instant invention utilizing the semicircular moving contact mechanism set forth in my copending application Serial No. 317,101, filed October 27, 1952, which matured to Patent No. 2,743,338 on April 24, 1956, is particularly adaptable for laminated bar configurations which are spaced close together. This is achieved by having a pair of moving contacts for each pair of terminal bars and so arranged that one of the moving contacts moves into the wedge shaped gap from either side of the bus. All of the contacts are controlled

from a single point and their operation occurs simultaneously.

The construction of my novel switch, when applied to a plurality of closely spaced parallel terminal bars, resolves all the vertical and horizontal forces so that the forces resulting from the contact pressure are completely self-contained in the switch with no external forces being exerted on the terminal bar structure.

Accordingly, a primary object of my invention is to provide a novel high current switch which is particularly adaptable for use with a plurality of spaced parallel terminal bars which are spaced apart a distance no greater than the thickness of the bars.

Another object of my invention is to provide a novel high current switch for terminal bars wherein all of the forces resulting from the contact pressure are self-contained in the switch so that there are no external forces on the bus to which the switch is connected.

A still further object of my invention is to provide a novel switch structure in which a pair of contacts simultaneously move in opposite directions to bridge a gap in a terminal bar.

A still further object of my invention is to provide a switch in which only two parallel bridging contacts will carry the same current as the associated terminal bar of the order of 6,000 amperes and higher with a temperature rise not exceeding that of the bus to which it is attached.

A still further object of my invention is to provide a novel high current switch having a pair of bridging contacts for each terminal bar with which it is associated wherein all pairs of contacts are simultaneously moved to bridge the gaps between the terminal bars.

These and other objects of my invention will be apparent from the following description when taken in connection with the drawings in which:

Figure 1 is a schematic wiring diagram illustrating one particular use of my novel high current switch used as a shortcircuiting switch.

Figure 2 is a side elevation view of my high current switch illustrating the control mechanism for simultaneously operating a pair of bridging contacts for an upper and lower pair of terminal bars.

Figure 3 is a side elevation view of my high current switch similar to Figure 2 with the crank mechanism of the switch removed and illustrates the three positions of the bridging contact, namely, closed, contact parting and open.

Figure 4 is a section view of my high current switch taken along the line and in the direction of the arrows 4—4 of Figure 3.

Referring now to the schematic diagram of Figure 1, I have shown a direct current source **10** which supplies current to a plurality of cells **11***a*, **11***b*, etc., which are connected in series.

The source voltage may be between 400 and 750 volts and since there are usually more than a hundred pots similar to **11***a* connected in series thereacross, the voltage across each cell is between 5 and 6 volts. The source is usually capable of delivering between 30,000 and 100,000 amperes to each of the cells connected in series.

If it is necessary to remove one of the cells, as, for example, cell **11***a*, a shortcircuiting switch **12** must be provided to shortcircuit the cell.

The bus bars **13** may consist of between 8 or more spaced parallel bars so that each bar will carry approximately 3,000 amperes. Since there are a pair of contacts associated with each pair of bars, it is necessary to design the switch to carry approximately 3,000 amperes during the period of time that the cell **11** is shortcircuited.

My invention is directed to the switch 12, the construction of which is shown in Figures 2, 3, and 4.

The plurality of spaced parallel bars is shown in the sectional view of Fig. 4.

For the sake of simplicity, I have shown only four spaced parallel bars 14*a*, 14*b*, 14*c* and 14*d*. However, it will be understood that the novel switch can be constructed and is readily adaptable to a terminal bar configuration having any number of spaced parallel bars.

The spaced parallel bars 14 may be of ¾" x 10" or 1" x 8", or other comparable dimensions.

Spacers 15 of insulating material, such as transite, are sandwiched between the spaced parallel bars 14. The spacers 15 may be of a width equal to the width of the bars 14.

It is in this type of installation that my switch is particularly adaptable. That is, when the plurality of terminal bars are spaced from each other by a distance not greater than the width of the bars.

The bars in each vertical line are comprised of a top or upper and bottom or lower section, designated, respectively, by the letters T and B, wherein a wedge shaped gap on each side separates the pair. Thus, as best seen in Figures 2 and 4, the lower terminal bar 14*a*B is spaced from the upper terminal bar 14*a*T by the wedge shaped gap 16R and 16L.

Diamond shaped insulating plates 17 and 18 parallel to the terminal bars 14 are positioned at the outer extremities of the switch to secure and position the operating components of the bridging contact members in a manner hereinafter more fully described.

The interrupting plates 17 and 18 may be a laminated insulation polyester or melamine resin with glass cloth or could be a metal with an insulating sleeve over the bolts 19T and 19B which secure the sandwiched combination of the copper terminal bars 14, the transite spacers 15 and the diamond shaped insulating plates 17 and 18.

The bolts 19T and 19B clamp the entire structure together and have Belleville washers 20B and 20T positioned below the nuts 21T and 21B in order to maintain proper pressure in the event of shrinkage of the insulation due to drying-out.

The top or upper terminal bars 14T and the bottom or lower terminal bars 14B are provided with a plurality of openings 22 which can receive appropriate bolts or clamping means in order to secure the switch to the terminal bars which shunt the cell or pot to be short-circuited.

As will be best seen in Figures 2 and 3, the switch is symmetrical about the vertical center line.

The diamond shaped interrupting plates 17 and 18 support the two operating shafts 22R and 22L.

The semi-cylindrical elongated contacts 23R and 23L each are provided with independent contact pressure springs 24 and are controlled from the operating shafts 22R and 22L through the linkage 25 in the manner fully described and set forth in my copending application Serial No. 317,101, filed October 27, 1952.

The contact members 23 are coated with a heavy silver plating. The manner in which the bridging contacts 23 coopereate with the stationary contacts formed by the wedge shaped gap between the top and bottom terminal bars 14 will hereinafter be more fully described.

As has been fully set forth in my copending application Serial No. 317,101, filed October 27, 1952, the rotation of the shafts 22 will rotate the associated bridging contact into and out of engagement with the stationary contacts.

In the shortcircuiting switch of my invention, the shafts 22R and 22L are rotated simultaneously so that the plurality of bridging contacts 23R and 23L are moved simultaneously. The shafts 22R and 22L simultaneously operated will now be described.

The crank 27R and 27L are, respectively, attached to the shaft 22R and 22L by pinning, keying or other suitable means, as best seen in Figure 2.

One end of the insulating link 28 is pivotally secured to one end of the crank 27R and the other end of the insulating link 28 is pivotally secured to one end of the crank 27L. Hence, rotation of one of the shafts will be transmitted through the insulating link 28 to rotate the second shaft in an opposite direction and at approximately the same rate of angular rotation.

A socket 29 is secured to one end of the operating shaft 22L and is provided with an operating handle 30 which may be manually controlled. The position of the components when the shortcircuiting switch is in the fully closed position is illustrated in Figure 2. It will be noted that any desirable means may be utilized in order to latch or lock the components in the closed position.

The switch is opened by rotating the handle 30 in a clockwise direction for approximately 60° as this will transmit a direct force to the operating shaft 22L and rotate this shaft in a similar 60° clockwise direction. In addition, the force from the operating handle will be transmitted through the crank 27L, the insulating link 28, through the crank 27R to thereby rotate the operating shaft 22R 60° in a counterclockwise direction.

The movement of the elongated semi-cylindrical contact during the operation of the switch from the fully closed position to the fully opened position is illustrated in the three views of Figure 3. The solid line illustrates the position of the contact when it is in the fully closed position, the broken solid line illustrates the position of the contact during the opening operation and the dotted line illustrates the position of the contact in the fully opened position.

The position of the crank 27L when the switch is in the fully open position is illustrated by the dotted line of Figure 2. As can be best seen in the right hand side of Figure 3, the bridging contact 23 initially has longitudinal movement imparted thereto by the rotation of the operating shaft 22 and after it engages the stationary contacts formed by the wedge shaped gap within the terminal bars 14, continued rotation of the shaft 23 merely rocks the bridging contact 23 until it is symmetrical with respect to the horizontal center line of the wedge shaped gap. Hence, since the final movement of the movable contact is a rotational movement, the initial surface of the movable contact which engages the stationary contact is not the same as the final surface which remain in permanent electrical engagement with the stationary contacts. If pitting should occur on the contact, it will not be on the surface of the movable contact which finally engages the stationary contact. The coating of heavy silver plating is all that is necessary to properly protect the movable contacts.

However, as is clearly seen in the moving picture view of Figure 3, the portion of the stationary contact which is initially engaged by the bridging contact member 23 is the same area that is finally engaged by the bridging contact. That is, since the bridging contact after initial engagement with the stationary contact no longer has longitudinal movement, it is instead restricted to rotational movement.

Both the initial and final contact area of the stationary contact is the same. Hence, if pitting should occur at this point, it will exist in the area of the stationary contact which is intended to carry current for an appreciable length of time. Thus, it can be seen that it is desirable to provide means to eliminate pitting of the stationary contact although this is not necessary for the movable contacts.

In Figures 2 and 3, I have illustrated one means whereby pitting of the stationary contact can be eliminated. This is achieved by brazing refractory pieces 30—31 of silver tungsten on the stationary contact of the portion of the terminal bar which is nearest to the operating handle. Thus, for example, silver tungsten pieces 30—31 will be

applied only to the gap 16L of the terminal bars 14—14*a*. Neither the remaining bars 14*a*, 14*b*, 14*c* nor the right hand side air gap 16R will have a silver tungsten piece 30—31.

As hereinafter noted, since all of the bridging contacts 23*a*R 23*a*L, 23*b*R, 23*b*L, 23*c*R, 23*c*L, 23*d*R 23*d*L are simultaneously operated and since a raised portion is provided on the lefthand side in the left wedge shaped gap of the terminal bars or 14*a*, the bridging contact 14*a*L will enage the stationary contacts before and disengage the stationary contacts after all of the remaining bridging contacts have engaged or disengaged, respectively.

Hence, any pitting which may occur will be confined to the wedge shaped gap 16L of the terminal bar 14*a* and more particularly will be confined to the silver tungsten pieces 30—31 which are brazed thereon.

Since the pitting will be confined to this particular area, after continued use of several hundred operations, the pitted silver tungsten pieces 30—31 can be removed and new pieces can be brazed thereon. In this manner, the bridging contact 23*a*L is considered the arcing contact confining any damage which may be done due to pitting of the pieces 30—31.

The shortcircuiting switch of my instant application is designed to carry current in the range of 3,000 amperes for each moving contact.

Since the width of the movable contacts 23 is limited to twice the width of the terminal bars 14, when the terminal bars are spaced from each other by a space not greater than the width of the bars, it is necessary to provide means to dissipate any excess of heat which may be generated by the I^2R losses. This is achieved by making the bridge contacts elongated semi cylindrical members so that the excess heat can be dissipated by radiation and convexion by the portion of the contact which is not in engagement with the terminal bars 14.

Since the shortcircuiting switch set forth in my copending applications Serial No. 317,101, filed October 27, 1952, and Serial No. 357,021, filed May 25, 1953, is designed primarily to have currents in the range of approximately 600 amperes for each contact. It is not necessary to provide an elongated contact and, hence, only the semi cylindrical contact is shown.

However, in my instant application, each bridging contact 23 would have to carry as much as 3,000 amperes and, hence, the elongated portion is provided for the reasons noted.

As will be clearly seen in Figures 2 and 3, the diamond shaped insulating bracket 17 is provided with a vertical portion 33. The diamond shaped bracket 18, a sectional view of which is seen in Figure 4, is also provided with a comparable vertical section 33.

When the switch is closed, the horizontal components of the reaction forces due to the contact pressure springs 24 are in opposite direction thereby balancing each other. That is, since the pair of moving contacts 23R and 23L move into the wedge shaped gap 16R and 16L from opposite sides of the busbar, the horizontal components of the reaction forces are balanced.

The vertical component of the forces tend to push the bottom of lower or terminal bars 14B down and the top or upper terminal bars 14T up away from the center of the switch. However, these reacting forces are balanced by tensional forces in the vertical portion 33 of the diamond shaped insulating brackets 17 and 18 which are located at both sides of the switch. Hence, the reacting forces due to the contact pressure springs 24 impart no strain on the bus to which the switch is connected.

In the foregoing, I have described my invention only in connection with preferred embodiments thereof. Many variations and modifications of the principles of my invention within the scope of the description herein are obvious. Accordingly, I prefer to be bound not by the specific disclosure herein but only by the appending claims.

I claim:

1. A high current switch comprised of a plurality of terminal bars; a pair of insulating brackets; a first and second operating shaft; and a first and second plurality of bridging contacts; said plurality of terminal bars spaced from each other by insulating means having a width approximately equal to the width of said terminal bars; said pair of insulating brackets secured to each side of said spaced parallel terminal bars and insulating means; said insulating plates supporting said first and second operating shaft; each of said terminal bars having a first and second wedge shaped gap communicating with each other; said first plurality of bridging contacts associated with said first gap in each terminal bar; said second plurality of bridging contacts associated with said second gap in each terminal bar; said first operating shaft being operatively connected to and controlling said first plurality of bridging contacts to engage and disengage said first wedge shaped gaps; said second operating shaft being operatively connected to and controlling said second plurality of bridging contacts to engage and disengage said second wedge shaped gaps; means to simultaneously control said first and second operating shaft.

2. A shortcircuiting switch comprised of a plurality of terminal bars, a pair of diamond shaped insulating brackets, a first and second operating shaft, and a first and second plurality of bridging contacts; said plurality of terminal bars spaced from each other by insulating means having a width approximately equal to the width of said terminal bars; said pair of diamond shaped insulating brackets secured to each side of said spaced parallel terminal bars and insulating means; said diamond shaped insulating plates supporting said first and second operating shaft; each of said terminal bars having a first and second wedge shaped gap communicating with each other; said first plurality of bridging contacts associated with said first gap in each terminal bar; said second plurality of bridging contacts associated with said second gap in each terminal bar; said first operating shaft controlling said first plurality of bridging contacts to engage and disengage said first wedge shaped gaps; said second operating shaft controlling said second plurality of bridging members for engagement and disengagement with said second wedge shaped gaps; means to simultaneously control said first and second operating shaft; said diamond shaped insulating plate balancing the horizontal and vertical forces of said switch thereby eliminating external forces.

3. A shortcircuiting switch comprised of a plurality of terminal bars, a first and second operating shaft, a first and second plurality of bridging contacts; said plurality of terminal bars spaced from each other by insulating means having a width approximately equal to the width of said terminal bars; each of said terminal bars having a first and second wedge shaped gap communicating with each other; said first plurality of bridging contacts associated with said first gap in each terminal bar; said second plurality of bridging contacts associated with said second gap in each terminal bar; said first operating shaft controlling said first plurality of bridging contacts into and out of bridging engagement with said wedge shaped gaps; said second operating shaft controlling said second plurality of bridging members for engagement and disengagement with said second wedge shaped gaps; refractory material on one side of said wedge shaped gaps to eliminate arcing or pitting on the remaining wedge shaped gaps; means to simultaneously control said first and second operating shaft.

4. A high current switch comprised of a plurality of terminal bars; a pair of insulating brackets; a first and second operating shaft; and a first and second plurality of bridging contacts; said plurality of terminal bars spaced from each other by insulating means having a width approximately equal to the width of said terminal bars; said pair of insulating brackets secured to each side of said

spaced parallel terminal bars; said insulating brackets supporting said first and second operating shaft; each of said terminal bars having a first and second wedge shaped gap communicating with each other; said first plurality of bridging contacts associated with said first gap in each terminal bar; said second plurality of bridging contacts associated with said second gap in each terminal bar; said first and second plurality of bridging contacts being semicylindrical elongated members to dissipate heat by radiation and convexion; said first operating shaft being operatively connected to and controlling said first plurality of bridging contacts to engage and disengage said first wedge shaped gaps; said second operating shaft being operatively connected to and controlling said second plurality of bridging members for engagement and disengagement with said second wedge shaped gaps; means to simultaneously control said first and second operating shaft.

5. A shortcircuiting switch comprised of a plurality of terminal bars; a pair of diamond shaped insulating brackets; a first and second operating shaft; and a first and second plurality of bridging contacts; said plurality of terminal bars spaced from each other by insulating means having a width approximately equal to the width of said terminal bars; said pair of diamond shaped insulating brackets secured to each side of said spaced parallel terminal bars and insulating means; said diamond shaped insulating plates supporting said first and second operating shaft; each of said terminal bars having a first and second wedge shaped gaps communicating with each other; said first plurality of bridging contacts associated with said first gap in each terminal bar; said second plurality of bridging contacts associated with said second gap in each terminal bar; biasing means for said first and second plurality of bridging contacts and said first and second operating shafts to achieve high pressure contact engagement with said wedge shaped gaps; said first operating shaft connected to control said first plurality of bridging contacts to engage and disengage said first wedge shaped gaps; said second operating shaft connected to control said second plurality of bridging members for engagement and disengagement with said second wedge shaped gaps; means to simultaneously control said first and second operating shaft; said diamond shaped insulating plates balancing all of the forces resulting from said biasing means thereby eliminating external forces of said switch.

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