

Nov. 17, 1942.

J. W. SEAMAN

2,302,394

ELECTRIC SWITCH

Filed Nov. 27, 1940

2 Sheets-Sheet 1

Fig. 1.

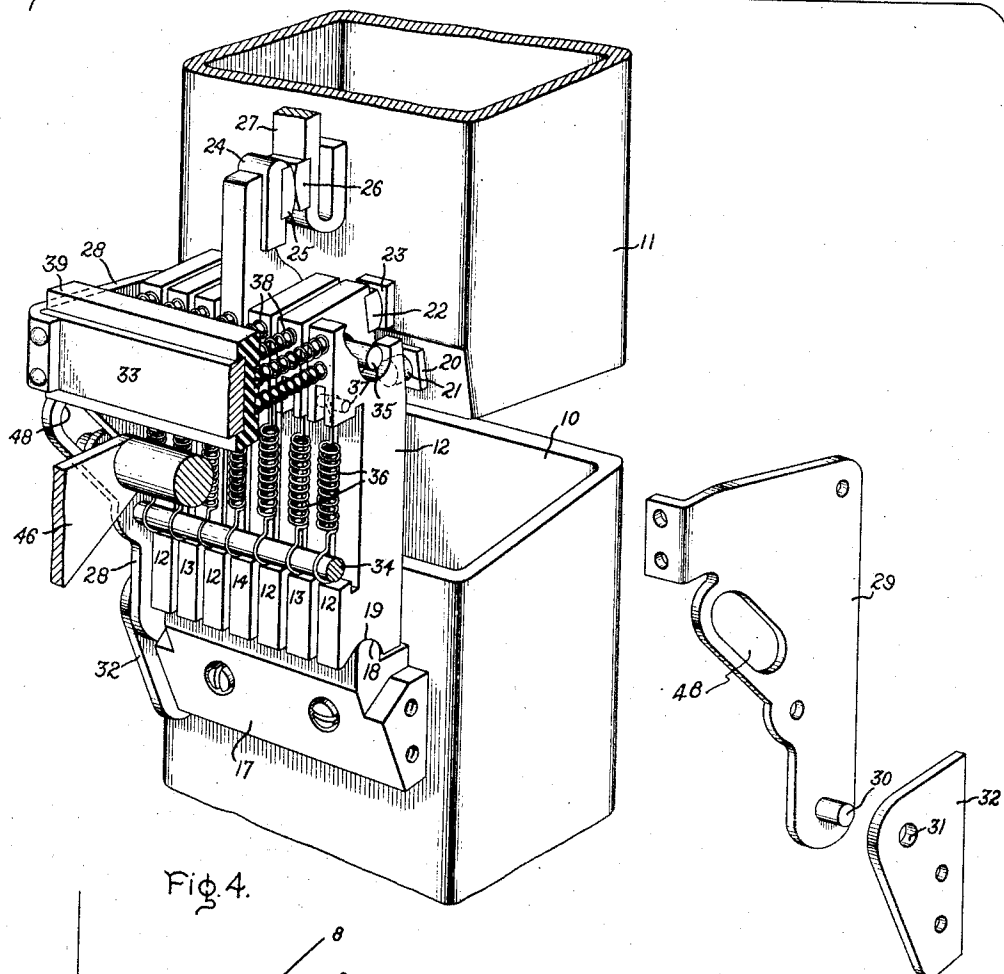
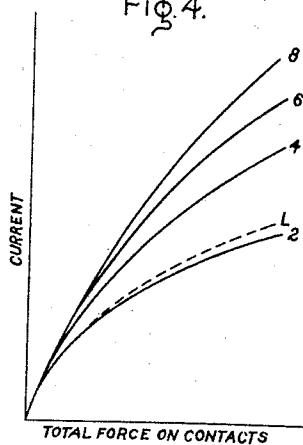


Fig. 4.



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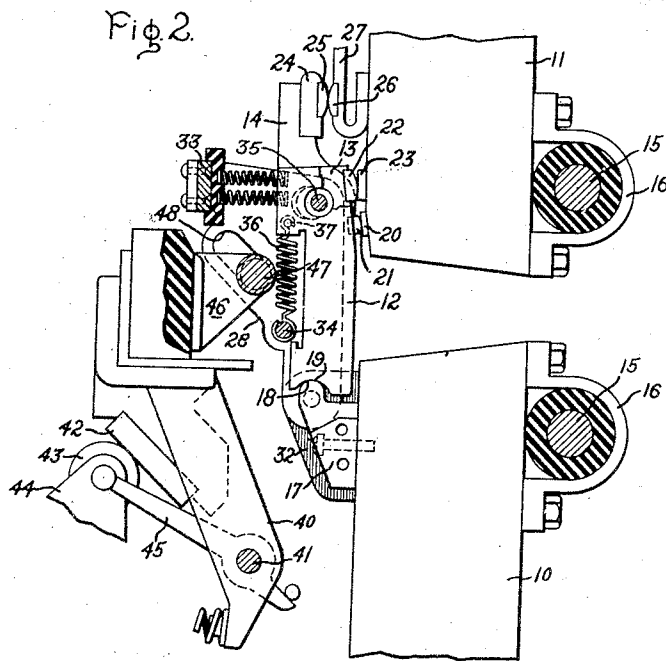
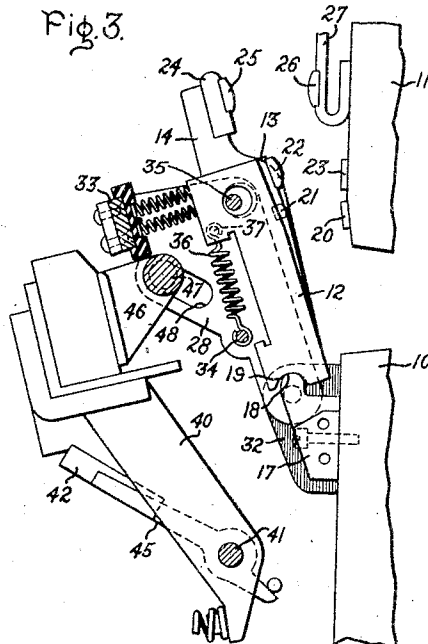
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ELECTRIC SWITCH

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2 Sheets-Sheet 2



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UNITED STATES PATENT OFFICE

2,302,394

ELECTRIC SWITCH

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Application November 27, 1940, Serial No. 367,386

17 Claims. (Cl. 200—146)

My invention relates to improvements in electric switches and more particularly switches for conducting large currents and especially circuit breakers.

The use of flexible and like current conductors in connection with the movable contacts of electric switches involves many difficulties. Such conductors, because of the open mechanical structure required for easy bending, deteriorate more rapidly from corrosion effects than solid conductors do. Moreover, since they must be mechanically weak in order to flex without the use of large forces, they are easily deformed and often broken. Furthermore, it is difficult so mechanically to mount them among the movable parts of circuit breaker mechanisms as to avoid mechanical interference and also the undesirable electromagnetic effects which arise in looped conductors particularly when they are carrying large currents.

High ampere carrying capacity switches require a movable contact of large cross section. If the contact is made in one solid piece, it is difficult to avoid overheating, particularly if the switch has to be enclosed. Moreover, the greater the mass of the movable conductor, the more the effort required to effect the movement and maintain the desired contact pressure necessary to avoid pitting, welding, etc. particularly during severe current inrushes which last for any appreciable time. From the standpoint of current transfer in the use of main, secondary and arcing contacts, it is difficult to obtain such a small difference between the reactance and resistance of the circuits through these respective contacts as to reduce contact damage at transfer to a reasonable minimum. Furthermore, it is economically unfeasible to machine and maintain cooperating planar contact faces to that nicety which will provide the maximum current carrying capacity with the minimum of maintenance. It is also difficult to provide with a relatively simple operating mechanism the necessary operating force to insure the requisite unit contact pressure.

One object of my invention is to provide an electric switch structure which does not require flexible conducting connections. A second object of my invention is to provide a high ampere carrying capacity movable contact structure which does not overheat, weld or pit even under momentary surges of current. A third object of my invention is to obtain the maximum current carrying capacity with a given applied contact pressure force. A fourth object of my invention

is to provide a contact structure which insures a maximum current carrying capacity with a minimum of maintenance. A fifth object of my invention is to provide a multi-unit bridging contact structure with pressure equalizing means such that each bridge carries its proportionate share of the current. A sixth object of my invention is to provide such an arrangement of main, secondary and arcing contacts as to minimize the reactance and resistance differences between the circuits through these contacts whereby to avoid any material damage to contact structure. These and other objects of my invention will hereinafter appear in more detail.

In accordance with my invention, I provide a multi-unit bridging contact structure which embodies the use of high pressure line and point contacts. Moreover, according to my invention, I so construct and arrange the main, secondary and arcing contacts that the differences between the reactances and the resistances of the circuits through these contacts is insufficient to produce damaging arcing during the transfer.

Further, in accordance with my invention, the units of the bridging contacts are spaced to insure better cooling. Also, in accordance with my invention, I mount the bridging contact units to move in unison about a contact axis whereby to avoid the use of flexible conductors. I further provide a pressure equalizing means such that relative movement of the units can occur to take care of mechanical tolerances of manufacture and assembly.

My invention will be better understood from the following description when considered in connection with the accompanying two sheets of drawings, and its scope will be pointed out in the appended claims.

In the accompanying drawings Fig. 1 illustrates in exploded perspective a switch contact structure embodying my invention; Fig. 2 is a side elevation partly in section of the switch structure shown in Fig. 1 with the contacts in the closed circuit position; Fig. 3 is a view similar to Fig. 1 showing the parts in the open circuit position; and Fig. 4 is a curve diagram illustrating the current carrying capacities of switches embodying my invention and one other form of switch.

In the illustrated embodiment of my invention two stationary spaced electric current conducting members 10 and 11 are arranged to be interconnected or bridged by a plurality of movable conducting elements such as bridging contacts 12, 13 and 14. For more effective cooling, conductors 10 and 11 may be tubular as shown al-

though, as far as my present invention is concerned, they may be solid conductors. Likewise for a more effective cooling, the bridging contacts 12, 13 and 14 may be spaced apart as shown in Fig. 1. The conductors 10 and 11 may be mounted on an open framework shown as comprising insulated rods 15 to which the conductors are suitably secured as by clamps 16. This open framework mounting also insures better cooling action particularly when the switch construction illustrated is used as a part of a so-called network protector since these devices are usually enclosed in metallic housings which are in turn frequently installed in closed vaults.

In order to obtain maximum conductivity with a given operating force and also to avoid the use of flexible conductors, the bridging contacts 12, 13 and 14 are, in accordance with my invention, arranged to bear on one of the conducting members, such as the lower member 13, in substantially line contact for movement on the member 10 and relatively to the members 10 and 11. For this purpose the member 10 may be provided with a substantially cylindrical conducting portion, herein shown as a projecting contact member 17 having a substantially cylindrical surface 18. This surface may take the form of a cylinder of revolution, but my invention is not limited to this specific type of surface since any arrangement which will provide a satisfactory line contact and permit the necessary movement is all that is required. Each of the bridging contacts 12, 13, and 14 is also provided with a substantially cylindrical contacting face 19 for engaging the cylindrical contacting face 18. For line contact the curvature of the faces 18 and 19 may differ as will appear more clearly from Figs. 2 and 3. Thus, for example, the radius of curvature of the face 19 may be greater than the radius of the curvature of the face 18. The angular extent of the cylindrical face 19 of the contacts 12, 13 and 14 is such as to prevent any possibility of the bridging contacts being moved out of engagement with the cylindrical surface 18 by shocks, jars or heavy current surges through the switch.

Further, in accordance with my invention, I provide means whereby the contact elements 12, 13 and 14 in the circuit closing position of the switch engage the member 11 in point and line contact. Thus, for example, the member 11 may be provided with suitable planar contacting surfaces, such as silver inserts 20, which are engaged by spherically faced contacting portions, such as silver inserts 21, on the main bridging contacts 12. The contacting faces of the inserts 20 and 21 thus provide substantially point contact. The plane surface of the contacting insert 20 may be inclined to the front face of the members 10 and 11 as shown more clearly in Figs. 2 and 3 since I have found that by so doing the current carrying capacity of the switch is very materially increased, particularly under heavy current surges, without damage to the switch parts. Certain of the bridging contacts, such as 13, may be arranged as secondary or transfer contacts to open following the opening of the main contacts. Thus the bridging contacts 13 may, in accordance with my invention, be provided with cylindrical or spherical contacting surfaces 22 which engage planar contacting surfaces 23 on the member 11 to provide either line or point contact, as desired. The contacting surfaces 22 and 23 may comprise suitable inserts in the bridging contacts 13 and the member 11, respectively. Since the bridging

contacts 13 act in the form of transfer contacts, the inserts 22 and 23 are preferably of suitable arc temperature resistant materials examples of which are well known to the art. The final break or arc interruption may be made by the bridging contact 14 which may be arranged for line contact with the member 11. For this purpose the upper end of the bridging contact 14 may be provided with a high current carrying and heat absorbing insert 24 of copper or other suitable material in which is set a cylindrically faced contact 25 of high arc temperature resistant material examples of which are well known to the art. A similar cylindrically faced arcing contact 26 is suitably mounted on the member 11 preferably on an arcing horn 27 suitably secured to the member so as to provide a desired blow-out effect.

With this contact structure, it will be apparent that the main, secondary and arcing contacts are so located as to obtain the minimum impedance differences between the circuits through these contacts because so much of the current path is inductively common to these circuits in consequence of the interleaving of the bridging contact elements. In other words, the impedance differences are kept at a minimum, whether A. C. or D. C. circuits are involved, since these differences are a function of the current path, and the minimum change in the current path is obtained by the contact construction used at the upper ends of the contacts. Also, since the main transfer and bridging contacts 12, 13 and 14, respectively, are so closely similar in form and arrangement, they tend to share the load equally under normal conditions. This is quite different from the usual air circuit breaker practice, and it aids materially from the standpoint of economy in cost and space. Furthermore, the pivotal arrangement of the movable contacts around a fixed conductor is of considerable advantage in that it is possible to keep the size of the operating mechanism to the smallest possible dimensions and cost and also to keep the contact structure to the minimum size, cost and resistance. These features are of particular advantage when my invention is used in network protectors.

In accordance with my invention, I provide means mounting the elements 12, 13 and 14 for simultaneous movement to and from contacting engagement with the member 11 such that the cylindrical surfaces 19 of the elements may move over the cylindrical face 18 of the contact portion 17 freely and keep these faces clean. As shown, this contact mounting means is a pivoted support whose pivotal axis is concentric with the axis of the cylindrical surface 18 of the contacting portion 17. This pivoted support comprises two side or frame members 28, 29, each having a pivot 30 which fits in an opening 31 in side brackets 32. These side brackets 32 are suitably secured to the contacting portion 17 on the member 10.

For movement as a unit the frame members 28 and 29 are rigidly secured to each other by a plurality of cross or tie members 33, 34 and 35 each of which has its individual function to perform. Thus, for example, the cross member 34 constitutes a part of a mechanism which provides pressure at the line contacts of the elements 12, 13, and 14 with the contact surface 18. This pressure producing means includes suitable resilient means, such as springs 36, one for each of the contact elements interconnecting the upper end of the element from a pin 37 therein to the cross member 34. With this arrangement, it will be obvious that the springs 36 carry substantially

no current so that they are unaffected by any heating effect due to currents therein. Moreover, since the pull of the springs 36 is exerted so closely in line with the contact between the surfaces 18 and 19, substantially the full effect of these springs is available to maintain the necessary contact pressure between the surfaces 18 and 19. The springs 36 also help to maintain the vertical alignment of the contact members 12, 13 and 14.

In order to equalize contact pressure at the upper ends of the contacts 12, 13 and 14 and at the same time permit the desired sequence of closing and opening of the contacts 12, 13 and 14, I provide suitable yielding or backing means, such as springs 38. These are shown as compression springs, two for each contact, extending between an insulating member 39 carried by the cross member 33 and the upper ends of the contacts 12, 13 and 14. Also, in order more definitely to control and restrain the motions of the upper ends of the bridging contacts 12, 13 and 14, I arrange to have the cross member 35 extend through openings in the upper ends of these contacts. In order to allow for the desired sequence of contact making and breaking of the different contacts at their upper ends, these openings are of different sizes with respect to the freedom of movement desired of the upper end of the contact member. Thus, for example, the cross member 35, as shown in the drawing, passes through a circular opening in the contacts 12 whereas it passes through what might be termed an elongated circular opening in the elements 13 and 14 so that the latter may partake of relative movement with respect to each other and the contacts 12.

For effecting the operation of the contact carrying mechanism to close the switch, any suitable type of operating mechanism, examples of which are well known to the art, may be employed. However, I have indicated in part a mechanism of the inclined plane and roller type such as disclosed, for example, in United States Letters Patent 2,034,146 assigned to the assignee of this application. As shown, this mechanism comprises a supporting member 40 which is mounted on a shaft 41 and provided with an inclined face 42. This face is engaged by a roller 43 on a suitably actuated operating member 44 which is restrained by a prop 45 pivotally mounted on the shaft 41.

In order to avoid lateral unbalance of the contact structure in consequence of the sequential operation of the contacts 12, 13 and 14, they may be symmetrically arranged as shown in the drawings, i. e., with the arcing element 14 in the center and the main and transfer elements 12 and 13 interleaved, as shown. This symmetry can be carried out with a greater number of each of the different kinds of contacts as will be apparent to those skilled in the art.

Inasmuch as in the illustrated embodiment of my invention, the axes of rotation of the supporting member 40 and the contacts 12, 13 and 14 are not concentric, the connection between the supporting member 40 and the contact carrier is arranged to compensate for the difference in alignment of these axes. For this purpose pivot carrying arms 46, extending from the supporting member 40, may be provided with pivots 47 which ride in slots 48 in the side plates 28 and 29.

Referring now to Fig. 4, the solid line curves 2, 4, 6 and 8 therein show the relation between the maximum peak inrush current, which I have

found from experiment point contacts could carry without severe pitting and welding, and the total force applied to the contacts. Curve 2 is for two point contacts in parallel; curve 4 is for four point contacts in parallel; curve 6 is for six point contacts in parallel; and curve 8 is for eight point contacts in parallel. The broken line curve L indicates the relation between the maximum peak inrush current, which a line contact could carry without severe pitting and welding, and the total force on the contact. From the foregoing curves, it will be observed that the line contact and two point contacts in parallel are substantially the same with respect to current carrying capacity. However, the current carrying capacity rapidly increases as the number of point contacts in parallel is increased, and also as the total applied force on the contacts is increased.

From experiments, I have found the following empirical equations to cover the relations between the pressure on the contacts, the current carried by the contacts, and the number of contacts, to be as follows:

$$f = 0.95i + 0.012i^{5/2}$$

$$F = N \left[0.95 \left(\frac{I}{N} \right) + 0.012 \left(\frac{I}{N} \right)^{5/2} \right]$$

$$f_1 = 1.58i + 0.016i^{2.6}$$

$$F_1 = N \left[1.58 \left(\frac{I}{N} \right) + 0.016 \left(\frac{I}{N} \right)^{2.6} \right]$$

In these equations the letters have the following significance:

- f equals force in pounds per point contact required to carry current i without a bad weld;
- i equals maximum peak instantaneous current in thousands of amperes per point contact;
- F equals total force in pounds on point contacts in parallel required to carry current I without a bad weld;
- N equals number of point contacts in parallel;
- I equals total maximum peak instantaneous current in thousands of amperes for N point contacts in parallel;
- f_1 equals force in pounds per point contact required to carry current i without any welding;
- F_1 equals total force in pounds on point contacts in parallel required to carry a current I without any welding.

From the foregoing equations as well as the curves shown Fig. 4, the rapid increase in current carrying capacity of multi-point contacts in parallel for a given applied pressure will be obvious.

While I have shown and described my invention in considerable detail, I do not desire to be limited to the exact arrangements shown, but seek to cover in the appended claims all those modifications that fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States, is:

1. An electric switch comprising two stationary spaced electric current conducting members, one of said members having a contacting portion, and means for establishing a plurality of parallel conducting paths between said spaced conducting members comprising a plurality of movable spaced rigid conducting elements each having one end continuously engaging said contacting portion in line to line contact forming an axis for angular movement of the element, and means for

simultaneously moving said elements to and from engagement with the other of said members, said elements being mounted with respect to said moving means for limited relative movement in their engagement with said other member.

2. An electric switch comprising two stationary spaced electric current conducting members, one of said members having a substantially cylindrical contacting portion, and means for establishing a plurality of parallel conducting paths between said spaced conducting members comprising a plurality of spaced conducting elements each having a cylindrical contacting portion which engages the cylindrical contacting portion of said one member and has a different curvature therefrom, and means for simultaneously moving all of said elements on the contacting portion of said one member to and from engagement with the other of said members, said elements being mounted with respect to said moving means for limited relative movement in their engagement with said other member.

3. An electric switch comprising two stationary spaced electric current conducting members, one of said members having a substantially cylindrical contacting portion and the other of said members having a substantially planar contacting portion, and means for establishing a plurality of parallel conducting paths between said spaced conducting members comprising a plurality of spaced conducting elements each having at one end a substantially spherical contacting portion and at the other end a substantially cylindrical contacting portion engaging the cylindrical contacting portion of said one member, and means for simultaneously moving all of said elements on the contacting portion of said one member to operate the spherical contacting portions to and from engagement with the planar contacting portion of said other member, said elements being mounted with respect to said moving means for limited relative movement in their engagement with said other member.

4. An electric switch comprising two stationary spaced electric current conducting members, one of said members having a substantially cylindrical contacting portion, and means for establishing a plurality of parallel conducting paths between said spaced conducting members comprising a plurality of spaced conducting elements each having at one end a substantially cylindrical contacting portion having a different curvature than the cylindrical contacting portion of said one member and continuously engaging the cylindrical contacting portion of said one member in line to line contact, and means for simultaneously moving all of said elements on the contacting portion of said one member to and from engagement with the other of said members, said elements being mounted with respect to said moving means for limited relative movement in their engagement with said other member.

5. An electric switch comprising two stationary spaced electric current conducting members, and means for establishing a plurality of parallel conducting paths between said spaced conducting members comprising a plurality of spaced conducting elements each continuously bearing on one of said members in substantially line contact, means for simultaneously moving all of said elements about their bearing on said one member into engagement with the other of said members, and means for independently biasing each of said elements into such line contact arranged to in-

terconnect said moving means and said elements.

6. An electric switch comprising two stationary spaced electric current conducting members, one of said members having a substantially cylindrical conducting portion, and means for establishing a plurality of parallel conducting paths between said spaced conducting members comprising a plurality of spaced conducting elements each having a substantially cylindrical conducting portion continuously bearing on the cylindrical portion of said one member, means independently biasing each of said elements into such bearing, and means for simultaneously moving all of said elements about their bearing on said one member into engagement with the other of said members including pressure equalizing means for permitting relative movement of the elements in their engagement with said other member.

7. An electric switch comprising two stationary spaced electric current conducting members, one of said members having a substantially cylindrical contacting portion and the other of said members having a substantially planar contacting portion, a plurality of spaced conducting elements each having at one end a substantially spherical contacting portion and at the other end a substantially cylindrical contacting portion bearing on the cylindrical portion of said one member, resilient means independently biasing each of said elements into such bearing, and means for simultaneously moving all of said elements about their bearing on said one member into engagement with the planar contacting portion of the other of said members including resilient pressure equalizing means for permitting relative movement of the elements in their engagement with said other member.

8. An electric switch comprising two stationary spaced electric current conducting members one of said members having a substantially cylindrical conducting portion, a plurality of spaced conducting elements each having a substantially cylindrical conducting portion bearing on and having a greater radius of curvature than the cylindrical portion of said one member, means independently biasing each of said elements into such bearing, and means for simultaneously moving all of said elements about their bearing on said one member into engagement with the other of said members including pressure equalizing means for permitting relative movement of the elements in their engagement with said other member.

9. An electric switch comprising two stationary spaced electric current conducting members, a plurality of spaced conducting elements each bearing at one end on one of said members in substantially line contact, certain of said elements being arranged at the other end to engage the other of said members in point contact and other of said elements to engage the other of said members in line contact, means independently biasing each of said elements into the line contact with said one member, and means for simultaneously moving all of said elements about their bearing on said one member into engagement with the other of said members.

10. An electric switch comprising two spaced stationary electric current conducting means, and means for establishing a plurality of parallel conducting paths between said spaced conducting members comprising a plurality of spaced conducting elements each bearing at one end on one of said members in substantially line con-

tact, and means mounting said elements for simultaneous movement to and from contacting engagement with the other of said members including a pivoted support, means interconnecting said support and said elements for continuously producing independent pressures at their respective line contact engagements, and means for permitting relative movement of the elements in their engagement with said other member.

11. An electric switch comprising two stationary spaced electric current conducting members, one of said members having a substantially cylindrical contacting portion, a plurality of spaced conducting elements each having at one end a cylindrical contacting portion engaging the contacting portion of said one member, and means mounting said elements for simultaneous movement to and from contacting engagement with the other of said members including supporting means pivoted for turning about the axis of the cylindrical contacting portion of said one member, means interconnecting said supporting means and said elements for producing pressure at the respective engaging cylindrical contact portions of the elements and said one member, and pressure equalizing means for permitting relative movement of the elements in their engagement with said other member.

12. An electric switch comprising two stationary spaced electric current conducting members, a plurality of spaced conducting elements each bearing at one end on one of said members in substantially line contact, certain of said elements being arranged at the other end to engage the other of said members in point contact and other of said elements to engage the other of said members in line contact, and means mounting said elements for simultaneous movement to and from contacting engagement with the other of said members including a pivoted support, resilient means interconnecting said support and said elements for producing pressure at the line contacts of said elements and said one member and resilient pressure equalizing means for permitting relative movement of the elements in their engagement with the other of said members.

13. An electric switch comprising two stationary spaced electric current conducting members, one of said members having a contacting portion, and a plurality of simultaneously movable parallel spaced conducting elements each having one end engaging said contacting portion for angular movement thereon to and from engagement with the other of said members, the lengths of said conducting elements from their point of contact with said one member to their contact engagement with the other of said members varying so that certain of said elements function as main contacts, others as transfer contacts and at least one as an arcing contact.

14. An electric switch comprising two stationary spaced electric current conducting members, one of said members having a contacting portion, and a plurality of simultaneously movable parallel spaced conducting elements each having one

end engaging said contacting portion for angular movement thereon to and from engagement with the other of said members, the lengths of said conducting elements from their point of contact with said one member to their contact engagement with the other of said members varying so that certain of said elements function as main contacts, others as transfer contacts and at least one as an arcing contact and said contacting elements being symmetrically arranged with respect to each other with said arcing contact element as the central element.

15. An electric switch comprising two stationary spaced electric current conducting members, one of said members having a contacting portion, a plurality of parallel spaced conducting elements angularly movable on said contacting portion in parallel planes to and from engagement with the other of said members, certain of said elements differing in length so as to function as main, transfer, and arcing contacts, respectively, and pivotally mounted means supporting all of said elements for initial movement thereof simultaneously about said contacting portion toward engagement with said other member comprising means for mounting said elements for movement relatively to each other whereby to engage and leave said other conducting member sequentially.

16. An electric switch comprising two stationary spaced electric current conducting members, one of said members having a contacting portion, a plurality of parallel spaced conducting elements, each having one end engaging said contacting portion for angular movement thereof to and from engagement with the other of said members, certain of said elements functioning as main contacts and others as stationary contacts, and pivotally mounted means supporting all of said elements for initial movement thereof simultaneously about said contacting portion toward engagement with said other member comprising means for mounting said elements for movement relatively to each other, all of said elements being symmetrically arranged on said supporting means to maintain the lateral balance of the contact structure in the opening and closing movements of the switch.

17. An electric switch comprising two stationary spaced electric current conducting members and means for establishing a plurality of parallel conducting paths between said spaced conducting members comprising a plurality of spaced conducting elements each simultaneously bearing on one of said members in substantially line contact, means for simultaneously moving all of said elements about their bearing on said one member into engagement with the other of said members, and means for independently biasing each of said elements into such line contact comprising resilient means connected between each of said elements and said moving means to exert a force always tending to turn the elements in the same direction about their bearing on said one of said conducting members.

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