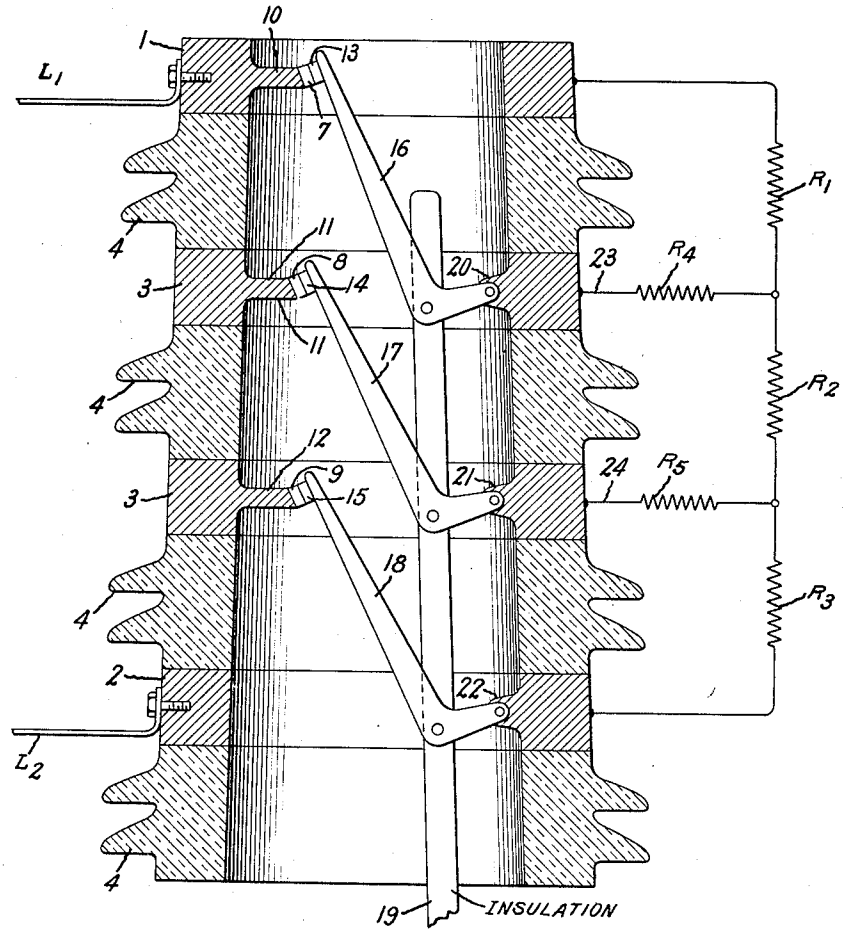
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MULTIBREAK CIRCUIT BREAKER WITH PROTECTIVE IMPEDANCES

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MULTIBREAK CIRCUIT BREAKER WITH PROTECTIVE IMPEDANCES

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This invention relates to multibreak circuit breakers, the interrupter elements of which are provided with an impedance arranged in shunt relationship with the several breaks or interrupter units thereof; and more particularly to the provision of additional impedance means which serve as a protection for the shunt impedance means in the event an arc restrikes across one or more of the several breaks.

In such high voltage multibreak circuit breakers wherein the several breaks or units of the interrupter are arranged in series, it is well known to provide a series of interconnected impedances, one in shunt relationship to each break, for the purpose of equalizing the voltage appearing across the several pairs of contacts especially during the critical period during and following the interrupting process. When these impedances are intended for this voltage distribution duty, they are so selected that the flow of current therethrough, when the breaker contacts open, is such that the voltage across the interrupter will be distributed among its breaks in proportion to their assumed strengths, thus permitting a maximum total voltage while minimizing arc re-establishment across any pair or pairs of contacts.

Other known applications of comparable shunt impedances are for the purpose of draining off a trapped charge on a capacitance being disconnected by the breaker (irrespective of whether this capacitance is lumped or in the form of a transmission line or cable) thereby controlling the overvoltage swings which characterize such an operation; while yet another purpose is that of controlling the rate of rise and crest voltage during the interrupting process of an inductive circuit, with or without current chopping. It is understood that such impedances would require different admittance values appropriate to the above-mentioned three functions; a relatively low value being required for potential division, one many times greater for capacitance switching, while that required for the third application usually is even greater still. It is further understood that impedance values chosen for one application will inherently possess, to a certain extent, the characteristics required for the other applications, so that for certain applications compromise values of admittance for the impedance means may be chosen which would be advantageous for two functions, for example, for capacitance switching as well as for voltage distribution among the breaks.

While such shunt impedances may take the form of resistors of linear type, it often is preferable to employ resistors having a non-linear current-voltage characteristic in which the resistance decreases in accordance with increase of the applied voltage. Such non-linear resistors have the advantage that their low resistance at high impressed voltages renders them effective for controlling these voltages, while their high resistance at normal voltages produces a relatively low wattage loss. However, the use of non-linear resistance elements is particularly subject to the hazard that, should the arc persist in one or more of the series breaks after being extinguished in the remainder, a relatively large current will flow through the series path comprising the arc in the first-mentioned break or breaks and the resistors in parallel with the last-mentioned break or breaks. This is because the low resistance path of the arc (compared to that of its corresponding resistor) in providing a preferred shunt current path therethrough, will cause a larger than normal portion of the total voltage across the interrupter to be applied to the non-linear resistances remaining in this series path so that the resistance thereof will be reduced substantially. Because of this hazard, shunt resistors as presently used must be made to withstand the effects of much higher current than would be required if positive and simultaneous interruption at all the breaks were assured.

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By way of illustrating the above hazard, if an arc persists across one of three series breaks, establishing therethrough a resistance negligible with repect to the shunting impedances, the voltage across the remaining impedances will be increased by 50%. If these impedances have a linear characteristic, the current through them will be increased in like proportion. The power dissipated in these impedances, which determines the rate at which their temperature rises, will therefore be increased in the ratio of 2¼ to 1. Should the arc persist across one of two impedances, the power dissipation ratio will be 4 to 1, while if two out of three impedances were shorted out by their associated arcs, the ratio would be 9 to 1. Although these high ratios would apply for only about one-tenth of the time during which voltage is applied to the impedances during a circuit opening operation, so that the over-all temperature rise resulting therefrom would be affected to a degree much less than that indicated by these given ratios, the additional burden is very substantial, nevertheless.

Furthermore, with non-linear impedances, the effect is considerably greater. For example, in one type of non-linear resistance having voltage ratios of 1½ to 1, 2 to 1, and 3 to 1, the current ratios respectively are 4.9 to 1, 15 to 1, and 72 to 1, with power ratios respectively of 7.3 to 1, 30 to 1, and 220 to 1. With such resistors constituting the shunt impedances of an interrupter, it follows that the overheating of one section resulting from the shorting out of other sections can assume dangerous proportions despite the transient nature of the heat-generating current-voltage conditions. Thus, in the known shunt impedance arrangements, a linear resistor is subect to moderately increased duty due to restriking of an arc across neighboring interrupting contacts; while a non-linear resistor under the same circumstances would be subjected to a duty of much greater severity.

Accordingly, it is an object of the invention to provide means for limiting the severity of current-heat conditions which can be imposed on the shunt impedances of a multibreak interrupter under certain arcing conditions.

According to the invention, in a multiple-break type interrupter having impedance elements connected in parallel with each interrupter unit or break, appropriate additional current-limiting impedance means are inserted in the interconnections between the circuit breaker contacts and the voltage-distributing impedances. By this means, whenever one impedance is shorted out by its corresponding arc, another compensating impedance is introduced into the circuit about the interrupter. Thus, the impedance of this additional current-limiting impedance means is available for combining with that of the voltage-distributing impedance means, thereby to greatly reduce any undesirable current-heat rise in the event of restriking or persisting arcs occurring across any of the breaks. By this arrangement, the parallel impedance elements around a multibreak interrupter may be designed more closely for the current associated with simultaneous operation of the breaks, without the necessity for making allowance for substantially increased duty arising from the hazard of non-simultaneous establishment of the several gaps from any cause.

The invention will be better understood in conjunction with the accompanying drawing, in which the single figure represents schematically a multibreak circuit interrupter having parallel impedances to which are connected the additional current-limiting impedances of the invention. It will be understood that the drawing is a representation of any known type multibreak interrupter such, for example, as that illustrated for the oil circuit breaker of United States Letters Patent 2,164,175 to Edward J. Frank, or it could be like that of the stacked high-voltage air-blast type circuit breaker disclosed in United States Letters Patent 2,419,446 to C. H. Flurscheim; both of these patents being assigned to the assignee of the present invention. Thus, it will be understood that, associated with the several interrupting breaks shown in the drawing, appropriate arc-quenching means such as a fluid blast, also voltage-isolating means which also interrupt the residual current in the impedances, such as an associated disconnecting or isolating blade as in Flurscheim, would be provided.

In the drawing, the conductors L_1 and L_2 constitute the terminals of the interrupter unit which is of generally cylindrical configuration, it being understood that the terminal L_2 usually connects to an isolating blade thereby to constitute a complete circuit breaker as noted above. This interrupter is shown as comprising a plurality of conducting ring-like spacer members **1**, **2** and **3** alternatively arranged, with appropriate insulating cylinders **4** which, for outdoor service, might be of the multi-hooded porcelain type somewhat as shown. Fixed contacts **7**, **8** and **9** are mounted on suitable projections **10**, **11** and **12**, respectively, which might be integral with the conducting rings **1**, **2** and **3**, as indicated. Movable contact tips **13**, **14** and **15** are provided for the contact arms **16**, **17** and **18**, respectively, these in turn being pivoted at their opposite ends to suitable fixed hinge lugs **20**, **21** and **22** which might constitute integral portions of the ring-like conducting members **3** and **2**. For producing simultaneous operation of the several contact breaks, the three contact arms each have a pivotal connection to a common insulating operating rod **19**; it being understood that other means, such as pressure gas, might be employed for producing comparable simultaneous operation as in the case of the above-mentioned Flurscheim patent.

Thus, for a circuit opening operation, the insulating operating rod would move upwardly responsive to actuating means, not shown, to produce simultaneous clockwise opening movement to the contact arms **16**, **17** and **18** about their respective pivotal mountings. Hence, simultaneous arcs are produced at the three contact breaks which, by the application of appropriate well-known blast action (not indicated), will be extinguished so that the circuit therethrough will be interrupted; following which further isolating gap means might be introduced through the agency of an associated isolating blade (not shown).

For the purpose of controlling overvoltages across the interrupter at the time of the circuit interruption, the known impedance means indicated by R_1, R_2 and R_3 are connected in shunt with the serially connected pairs of interrupter contacts and, so as to more equally distribute the voltage appearing across the interrupter among the several pairs of contacts while interrupting, these impedances preferably are connected individually by tap-off connections **23** and **24** in shunt with their associated contact pairs **7** and **13**, **8** and **14**, **9** and **15**, respectively. As already explained, such impedance means may be resistors of the non-linear type. In such a case, i. e., without the additional current-limiting impedance of our invention, if an arc should persist or restrike across contacts **9** and **15**, for example, an increased voltage would appear across resistors R_1 and R_2 and cause an excessive current to flow therethrough by reason of the arc **9—15** shunting out its parallel resistor R_3.

According to the invention, we provide additional current-limiting resistors R_4 and R_5 (which may be of the linear type even though the resistors R_1, R_2 and R_3 might preferably be non-linear) and insert them in the connections **23** and **24** between the conducting rings **3** and the junction points between resistors R_1 and R_2, and resistors R_2 and R_3, respectively, as clearly indicated on the drawing. With the new impedance arrangement, and assuming a similar arc restriking condition as in the example given above, the current path through the interrupter in this case would divide through the protective resistor R_5 in parallel with the resistor R_3, thereby to reduce the burden on the other interrupter shunt impedances. Thus, whenever an arc shunts out

its corresponding resistor R_1, R_2 or R_3, one or other of the current-limiting impedances R_4 and R_5 will be introduced into the total resistor circuit about the interrupter.

In one example of non-linear resistors in a two-break circuit breaker and with both pairs of contacts in the open position, the two resistors such as R_1 and R_2 pass a current of 5 amperes at the line voltage. Should one arc restrike across one break with the other arc extinguished at the other break, the current will flow through only one of the non-linear resistors and one arc, so that substantially the whole of the line voltage then appears across the one non-linear resistor to produce a current of some fifteen times that normally carried by that resistor; so that the magnitude of current through this non-linear resistor carrying the burden would be approximately 75 amperes. Obviously then, in such known arrangements, the non-linear resistors necessarily would have to be constructed to safely withstand these possible extreme currents which are so very large compared to the normal current flow through the two resistors in series. However, with our invention, the current-limiting impedance means such as R_4 and R_5 are available for being introduced effectively in series with the restriking or persisting arc, and can be given such a value as to limit the arc current to proportions that can be effectively extinguished without danger of damage to the non-linear shunt resistors, or to the additional current-limiting resistors. As already mentioned, the advantages of the invention are obtained even though the shunt impedances such as R_1, R_2 and R_3 are constituted by linear resistors, or even capacitors; but in such cases the hazard of damage from the above-discussed causes would be substantially less than when such impedances are of the non-linear type.

While certain embodiments of the invention have been shown or described, it will be obvious to those skilled in the art that various changes and modifications may be made without departing from the invention in its broader aspects, and it is intended therefore to set forth in the claims all such changes and modifications as fall within the true spirit and scope of the invention.

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

1. An electric circuit interrupter comprising a plurality of pairs of contacts connected in series and arranged to be operated substantially simultaneously, first impedance means forming a shunt circuit in parallel with said series-connected pairs of contacts, circuit means interconnecting the conducting structure between said pairs of contacts and intermediate points of said first impedance means, and second impedance means in series with said circuit means.

2. An electric circuit interrupter comprising a plurality of pairs of contacts connected in series and arranged to be operated substantially simultaneously, non-linear resistance means forming a shunt circuit in parallel with said series-connected pairs of contacts, circuit means interconnecting the conducting structure between said pairs of contacts and said non-linear resistance means, said circuit means being so connected to said non-linear resistance means that a predetermined portion of the total impedance of said non-linear resistance means is in parallel with each pair of said contacts, and additional resistance means arranged in series with said circuit means.

3. An electric circuit interrupter comprising a plurality of pairs of contacts connected in series and arranged to be operated substantially simultaneously, linear resistance means forming a shunt circuit in parallel with said series-connected pairs of contacts, circuit means interconnecting the junction points between said pairs of contacts and said linear resistance means, said circuit means being so connected to said linear resistance means that a predetermined portion of the total impedance of said linear resistance means is in parallel with each pair of said contacts, and substantially linear resistance means arranged in series with said circuit means.

4. An electric circuit interrupter comprising a plurality of pairs of contacts connected in series and arranged to be operated substantially simultaneously, non-linear resistance means forming a shunt circuit in parallel with said series-connected pairs of contacts, circuit means interconnecting the conducting structure between said pairs of contacts and said non-linear resistance means, said circuit means being so connected to said non-linear resistance means that a predetermined portion of the total impedance of said non-linear resistance means is in parallel with each pair of said contacts, and linear resistance means arranged in series with said circuit means.

5. A multi-break circuit interrupter having a plurality of serially related interrupting units, impedance means shunting at least an adjacent pair of said interrupting units, and additional impedance means connected between a junction between said adjacent two interrupting units and a point on the first-mentioned impedance means.

6. A multi-break circuit interrupter having a plurality of serially related interrupting units, voltage dependent impedance means shunting at least an adjacent pair of said interrupting units, and other impedance means connected between a junction between said adjacent two interrupting units and a point on said voltage dependent impedance means.

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