

Jan. 4, 1944.

R. SCHADE
VARIABLE RESISTOR
Filed June 10, 1940

2,338,458

2 Sheets-Sheet 1

Fig. 1.

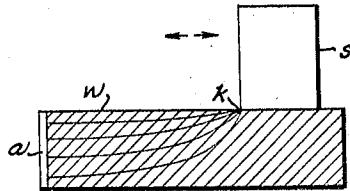


Fig. 2.

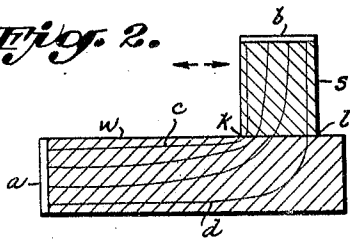


Fig. 3.

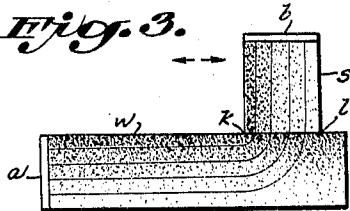


Fig. 4.

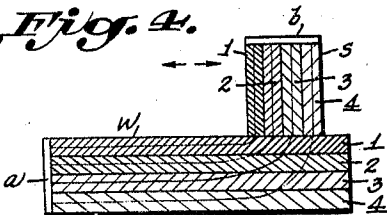
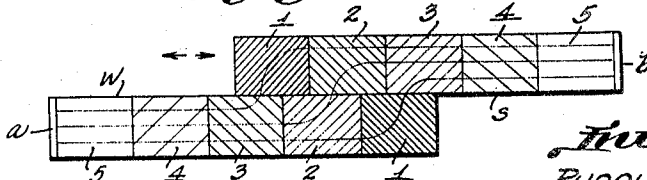


Fig. 5.



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Fig. 6.

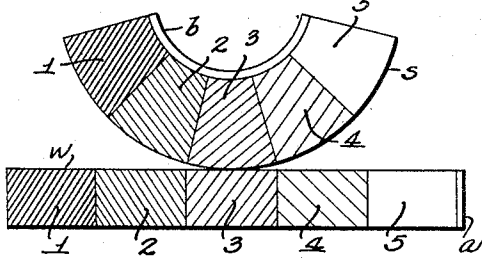


Fig. 10.

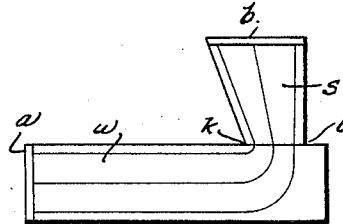


Fig. 7.

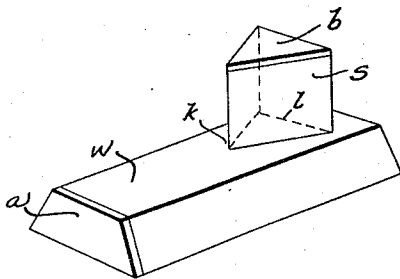


Fig. 11.

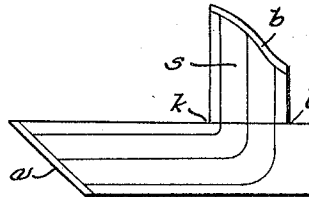


Fig. 8.

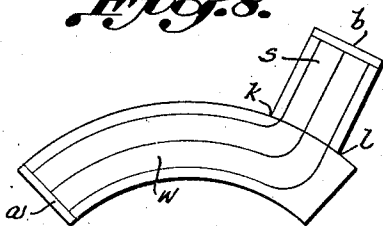


Fig. 12.

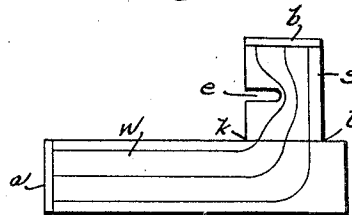
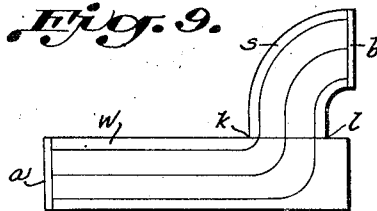


Fig. 9.



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UNITED STATES PATENT OFFICE

2,338,458

VARIABLE RESISTOR

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Application June 10, 1940, Serial No. 339,725
In Germany June 10, 1939

9 Claims. (Cl. 201—55)

The invention relates to variable resistors having a contact cooperating with the resistor and which instead of the switch devices hitherto known are to be employed alone or in connection with residual current circuit breakers to interrupt power circuits. Such resistors carry a very high load and must be varied very rapidly, so that disturbing influences occur at the contact surface which may so unduly stress the resistor and contact as to damage them within a short time. These influences are on the one hand the cause of unduly high current densities with subsequent excessive heating and wear and tear, particularly at one edge of the contact, and on the other hand of a sparking at this edge with similar consequences. According to the invention such influences are avoided by suitable means.

The invention is illustrated in the accompanying drawings, in which—

Fig. 1 is a side elevational view of a typical form of a resistor, illustrating schematically, the non-conformity of current paths characteristic of such devices in prior use;

Fig. 2 is similar to Fig. 1, except that the current paths are of a smaller load than shown in Fig. 1;

Fig. 3 is a similar elevational view showing a form of resistor contemplated by the invention in which the specific resistance of the materials of the resistor are varied, and the change in the distribution of the current paths effected thereby is illustrated diagrammatically;

Fig. 4 is a side elevational view schematically showing a different embodiment of the invention in which different specific resistivity of parts is obtained by constructional features other than the non-homogeneous of the bodies comprising the resistor;

Figs. 5 and 6 are modifications of the resistor shown in Fig. 4;

Fig. 7 is a perspective view of a modified resistor in which specific resistivity is obtained by the shape of the resistor; and

Figs. 8 to 12 are side elevational views of a schematic nature, showing modifications of the resistor illustrated in Fig. 7.

The current is caused according to the invention to flow along such paths in the resistor, contact or in both parts as to prevent an undue crowding of the current paths at one edge of the corresponding contact surface. Fig. 1 of the drawings illustrates the undesired crowding of the current paths if the contact *s* consists as is usual

entirely of metal. If the conductivity of the contact is indefinitely great as compared to the resistor *w*, the current paths are crowded at the edge *k* of the contact *s* spaced from the current junction *a* even if they enter the resistor at the current junction *a* uniformly distributed. The current density is also indefinitely great at the current junction. This is due to the unequal length of the current paths along the upper and lower side of the resistor. The detrimental effects mentioned above are already brought about upon merely approaching the theoretical limit illustrated in the drawings, that is to say, in the case of the definite conductivity of the usual metal contacts.

According to the invention the crowding of the current paths is prevented either by suitably selecting or distributing the specific resistance of the resistor, contact or of both parts, also by giving the one or the other part a suitable shape, further by suitably distributing the contact resistance over the corresponding contact surface as well as by suitably distributing the contact pressure over this surface or by selecting and distributing the conductive resistance. The means, whereby this may be accomplished, may also be combined in various ways.

The resistance in the different current paths may be made equal to a certain extent, if the contact and resistor are made of the same material. The distribution of the current paths thereby obtained is roughly illustrated in Fig. 2. In this case the contact edge *k* carries a considerably smaller load than according to Fig. 1, this, however, being disadvantageous for certain instances. The resistance in the current path *c* extending along the upper surface of the resistor *w* and the left-hand surface of the contact *s* is smaller than that in the current path *d* extending near the lower surface of the resistor *w* and near the right-hand surface of the contact *s*. A greater current density will therefore be brought about in the neighborhood of the left-hand contact edge *k* than in the neighborhood of the edge *l*. Consequently, the resistance in the different current paths between the two current junctions or terminals *a* and *b* of the resistor *w* and contact *s* respectively is rendered according to the invention as uniform as possible.

An effective improvement is obtained if the specific resistance of the contact varies along the surface in engagement with the resistor. Also a variation of the specific resistance of the resistor contributes in bringing about the same resistance in the different current paths. The stippled sur-

face illustrated in Fig. 3 indicates according to the invention the variations of the specific resistance of the resistor w and contact s , the points at which the dots are more crowded indicating a greater resistance. Along the contact surface the specific resistance of the resistor w is greatest. The current flowing from the current junction a tends therefore to follow paths towards the lower side of the resistor, i. e., away from the dangerous point k . By increasing the specific resistance of the contact s with respect to its edge k the current paths may also be shifted away from this edge so as to prevent an undue current density at this edge.

The specific resistance of the contact and that of the resistor may also vary according to the same law along the surface serving for the passage of the current, so that the drop of the specific resistance is approx. the same in both bodies.

Fig. 4 shows an embodiment of the invention which is somewhat less complicated than the non-homogeneous bodies w and s according to Fig. 3. These bodies consist as shown in Fig. 4 of individual layers 1...4 of different specific resistance, the different shadings indicating a distribution of the specific resistance and of the current path as illustrated in Fig. 3.

The change in resistance is also adapted to the manner in which the contact moves. If the contact slides on the resistor it may be preferable to uniformly vary in opposite directions the specific resistance of both parts along the surface serving for the passage of the current. Fig. 5 shows such an embodiment in which the contact is designed as is also the resistor in the form of a rod or plate. Both bodies consist of sections 1...5 of a different specific resistance, arranged in opposite sequence. As will be seen from the current paths shown in Fig. 5 the distribution of current at the contact surface is symmetrical with respect to the center of the latter. Consequently, an undue current density cannot occur at this edge. The main portion of the current passes between parts of the same specific resistance (here, for instance, between 2—2). It would even suffice when giving the resistor and contact the same shape to make both parts of approx. the same material having the same specific resistance, since also the symmetry of the distribution of current is then ensured. The form of the invention shown in Fig. 5 is, however, more advantageous, since the specific resistance at the outer edges of the two parts sliding on one another is greatest and an undesired increase in current density is avoided at these points. The two parts w and s may be moved in opposite directions in order to increase the control speed.

If the resistor and contact or one of these bodies is given a cylindrical shape, i. e., the one body rolls on the other, the specific resistance along the rolling surface serving for the passage of the current may vary preferably in the same direction along this surface. The rolling body consists, for instance, as shown in Fig. 6 of sectors 1...5 of different specific resistance. Both the resistor and the contact are preferably subdivided into sections of different resistances. In this case the arcs of the sectors of the rolling body should be equal to the lengths of the sections of the resistor, so that only parts of equal specific resistance come into contact. Consequently, the specific resistance in the contact increases in the same direction as that in the resistor.

Figs. 7 to 12 show further instances for pre-

venting an undue crowding of the current paths or at least their causes by giving the bodies employed a suitable shape.

The shape may be given either by varying the cross-section or the longitudinal section of the resistors or contacts.

According to Fig. 7 the cross-section of the resistor and contact is enlarged at the outer side of the angle or arc formed by the current paths. The apex of said angle coincides with the edge of the contact. About this edge the current paths are bent in an angle- or arc-like manner as will be seen, for instance, from Figs. 2 to 4. Since the innermost current path with respect to the edge k is the shortest, the width of the resistor and contact is smallest at this point according to Fig. 7 and is enlarged towards the opposite cross-section edge l . The center of gravity of the current carrying cross-section is thereby shifted from the dangerous point and the heat produced is therefore more uniformly distributed. Furthermore, the point k of the greatest current density is best cooled.

In the following embodiments the resistors, contacts or both are given such a shape in the longitudinal section that the current paths have the same length. According to Fig. 8 the longitudinal section of the resistor w and according to Fig. 9 of the contact s is so curved that the center of curvature is opposite to the current junction of the other part. In this manner the current path lying near the edge k is lengthened and a concentration of the current in this path is prevented. According to Fig. 10 the longitudinal section of the contact has a wedge-like shape, whereby the current path in said section extending near the edge k is longer than that extending near the edge l . Also this contributes to bring about a uniform distribution of current in the contact cross-section. A similar shape may also be given to the resistor w . In order to attain the same length of the current paths the surfaces a and b of the resistor w and contact s may be inclined with respect to the central current path in these bodies and, if desired, curved in a suitable manner, as will be seen from Fig. 11. A similar effect may be attained according to Fig. 12 by the fact that the current paths at the inner side of the angle or arc formed by the same are lengthened, for instance, by notches e provided in the contact s . All the embodiments described above may be combined in any suitable manner.

If the distribution of current in the contact surface is to be rendered uniform by the selection of the contact resistance, the contact resistance at the edge k of the contact near the current junction a of the resistor must be made greater than that at the opposite edge l . The contact resistance must decrease uniformly or gradually towards the edge l in order that the current paths be shifted away from the dangerous edge k of the contact. The contact resistance may be influenced by suitably machining the brush surface in contact with the resistor, by metal or insulating material coatings suitably distributed over this surface or in any other suitable manner.

The distribution of current over the contact surface may be further influenced by gradually increasing the contact pressure on this surface. The contact pressure is preferably smallest at the edge k of the contact s and increases towards the opposite edge l . This may be effected in a simple manner by an asymmetrical current load

of the contact according to the invention. The contact depending upon the manner in which it is secured to its support may be subjected to a tilting moment which tends to tilt it about the edge 7.

The invention herein disclosed has been set forth with particularity as to certain forms or embodiments for illustrative purposes, but it is obvious to those skilled in the art that modifications may be made without departing from the scope of the invention as defined by the appended claims.

What is claimed is:

1. A variable resistor for controlling heavy currents, comprising a body of resistance material and a contact member also formed of resistance material, said member having a surface in sliding engagement with said body at points spaced lengthwise thereof, and said body and contact member being composed of sections of different specific resistivity, said sections being arranged with respect to their resistivity so that the current paths have substantially the said resistance, whereby the current is caused to flow through the body and contact member along paths which do not converge at the edge of the contact surface which is nearest to the terminal end of the said body.

2. A variable resistor for controlling heavy currents, comprising a body of resistance material and a contact member also composed of resistance material, said contact member having a surface in sliding engagement with said body which is at least approximately equal in area to the transverse cross-sectional area of said body, and said body and contact member being composed of sections of different specific resistivity, said sections being so arranged with respect to their resistivity that the current is caused to flow through the said body and contact member along paths which are substantially parallel in said body and which have substantially equal resistances.

3. A variable resistor comprising a resistance body and a contact member in slidable engagement therewith, said resistance body and contact member having portions of different specific resistivity, whereby undesirable concentration of the current paths through the resistance body and contact member is prevented by a gradation in the specific resistivity of different portions of the said body and contact such that the shorter current paths extend through material of higher specific resistivity.

4. In a variable resistor, a block of resistance material having a terminal at one end, a contact member having one end in sliding engagement with said block and having a terminal at the other end, the said block and contact member being composed of parts of different specific resistivity, and the said parts being so distributed with respect to the length of the current paths which extend through the block and contact member from terminal to terminal that said current paths are of substantially the same resistance.

5. A variable resistor for controlling heavy currents, comprising two blocks of resistance material disposed substantially at right angles to each other with the end of one block in sliding engagement with the side of the other block, terminals for said blocks at the ends thereof, each terminal establishing a conductive contact with the associated block throughout the entire area of the end thereof, and current paths of equal resistance connecting all points on the contact face of one terminal with corresponding points on the contact face of the other terminal.

6. In a variable resistor for controlling heavy currents, two bodies formed of resistance material and disposed in sliding engagement with each other, terminals for including said bodies in an electrical circuit, and current paths extending through said bodies between said terminals which are made equal in resistance by gradation in the specific resistivity of different parts of said bodies.

7. In a variable resistor for controlling heavy currents, a resistance body built up of layers differing in specific resistivity, a terminal at one end of said body in direct conductive connection with all said layers, a contact block also built up of layers differing in specific resistivity, said block having a contact surface intersecting all the layers thereof in sliding engagement with that layer of said body which has the highest specific resistivity, and the said block being so oriented that the layer thereof having the highest specific resistivity is nearest to the terminal end of said body, and a terminal for said contact block in direct conductive connection with all the layers thereof.

8. A variable resistor for controlling heavy currents, comprising a rigid self-supporting slab of resistance material having a metallic terminal at one end thereof, a contactor comprising a block of resistance material having opposite ends of substantially the same area, one end having a metallic terminal secured thereto and the other end being in sliding engagement throughout its area with the side of said slab, and current paths extending from terminal to terminal through said slab and contactor which are uniformly distributed over the area of contact between the slab and contactor, said extension and distribution of current paths being effected by providing said slab and contactor with portions having different specific resistivity and arranging the portions so that the shorter current paths extend through the resistance material of higher specific resistivity.

9. In a variable resistor, a block of resistance material and a contact member in slidable engagement therewith, terminals for including said block and contact member in an electrical circuit, and current paths extending through said block and contact member which are uniformly distributed over the area of contact between the block and contact member by a gradation in the specific resistivity of different parts thereof.

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