March 20, 1945. W. J. GILSON 2,371,755

DISCONNECTING SWITCH

Filed June 21, 1943

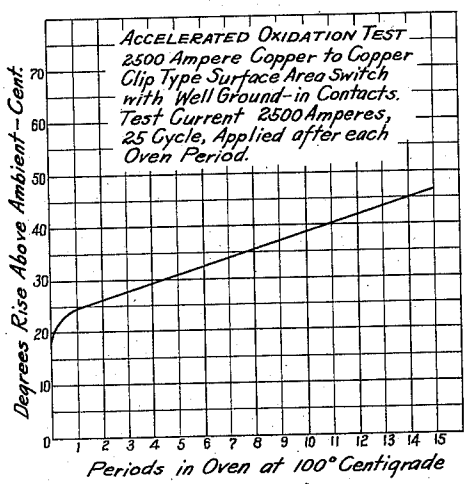


Fig. 1.

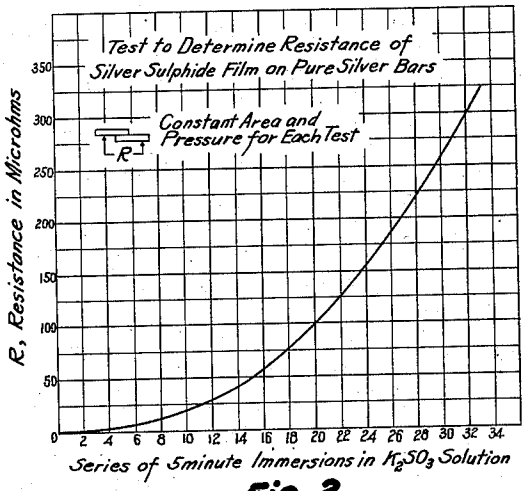


Fig. 2.

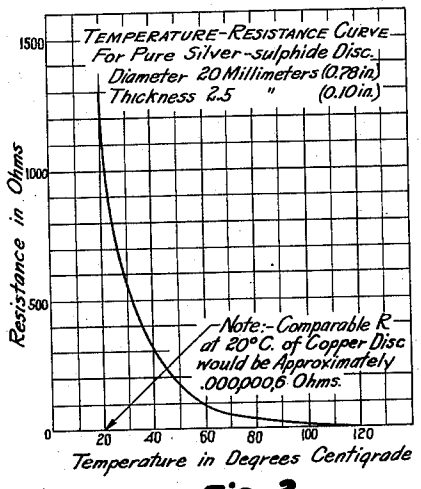


Fig. 3.

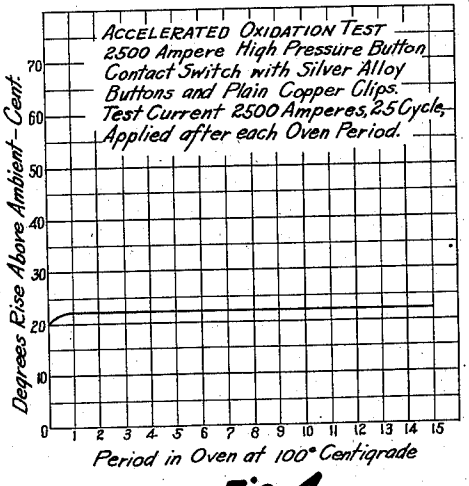


Fig. 4.

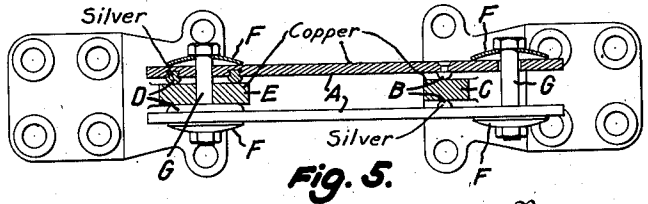


Fig. 5.

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Patented Mar. 20, 1945 2,371,755

UNITED STATES PATENT OFFICE

2,371,755

DISCONNECTING SWITCH

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Application June 21, 1943, Serial No. 491,686

12 Claims. (Cl. 200—162)

This invention relates to disconnecting switches such as used on power lines, and is particularly directed to the provision of disconnecting switches that have a substantially constant contact resistance, and therefore a substantially constant operating temperature, over long periods of use under conditions that develop films of high resistance material upon the contact surfaces.

The oxidation of the current-carrying surfaces of disconnecting switches of the copper-to-copper contact type results in a progressive increase in heating of the switch by the normal current, and it has been customary to inspect such switches periodically to remove the copper oxide films. This maintenance routine is expensive and, unfortunately, it has not in practice provided a positive assurance against failure. The oxide formations can be prevented by plating or brazing a film of silver over the cooperating copper contact surfaces, but silver-to-silver contact surfaces tend to roughen or "freeze," and the brazed-on silver layers may be stripped from the copper backing.

According to the present invention, the desired stabilization of the operating temperature of the disconnecting switch is obtained through the use of cooperating contacts of copper or a copper alloy and silver or a silver alloy. This application is a continuation-in-part of my copending application Ser. No. 350,866, filed August 3, 1940.

The principal objects of this invention are to provide disconnecting switches having cooperating contact surfaces that preclude the progressive rise in temperature, and the ultimate failure in the absence of periodic inspection and cleaning, that is characteristic of prior disconnecting switches in which films of high electrical resistance develop upon the metal contact surfaces under varying temperature and atmospheric conditions and, more particularly, to provide disconnecting switches having contact surfaces of differing materials, which, under the influence of current flow and changes of temperature and atmospheric conditions, will react to produce and maintain a contact engagement of high electric conductivity. An object is to provide a disconnecting switch, for power service, in which the cooperating blade and/or terminal members have raised portions for restricting the contact engagement to the order of line or point contacts, each pair of cooperating contact surfaces being respectively of copper and of silver. More specifically, an object is to provide a disconnecting switch of the type stated in which the silver contact surfaces are hardened and are backed up by relatively heavy masses of silver.

The principal feature of the invention consists in the use of cooperating contacts of two separate types of metal which produce surface films, through the effect of temperature and atmosphere, that are individually of relatively high resistance but that, when in contact and subject to heating by the normal current through the switch, are conducive to electric conductivity; such separate types of metal being, for instance, copper or copper alloys and silver or silver alloys.

These and other objects and advantages of the invention will be apparent from the following specification when taken with the accompanying drawing in which:

Fig. 1 is a graph showing the increase in the temperature developed under load by a disconnecting switch, of known copper-to-copper contact type, with increase in the thickness of oxide films at the contact surfaces;

Fig. 2 is a graph showing the increase in the contact resistance of silver-to-silver contacts with increase in the thickness of the silver sulphide films on the contact surfaces;

Fig. 3 is a graph showing the temperature-resistance characteristics of silver sulphide;

Fig. 4 is a graph showing the resistance-film thickness characteristic, in terms of temperature rise under normal current load, of a disconnecting switch embodying the invention; and

Fig. 5 is a plan view, with parts in section, of a disconnecting switch embodying the invention.

In the manufacture of disconnecting switch mechanisms many different types of structures have been devised which are allegedly of a self-cleaning form and such structures have been developed with varying degrees of efficiency for both copper-to-copper and silver-to-silver contacts. The so-called self-cleaning action maintains reasonably good contacts under some operating conditions but, when the disconnecting switches are operated infrequently, the contact surfaces acquire a corrosive film which becomes to heavy to be cleaned off by ordinary opening and closing operations.

In order to determine the result of film formation on the conventional copper-to-copper and silver-to-silver contacts, measurements were made of the operating temperature, or the contact resistance, of disconnecting switches that were subjected to conditions that promoted the formation of high resistance films on the contact surfaces. The formation of oxide films on a copper-to-copper clip type surface area disconnect-

ing switch of 2500 ampere capacity was accelerated by placing the switch in an oven that was held at a temperature of 100° C. and continuous high humidity. The temperature rise of the switch, when carrying its rated load of 2500 ampere alternating current of 25 cycles per second, was measured after successive periods of five days each in the oven, and the relation between the temperature rise and the number of exposures to oxidation-producing conditions is shown by the graph of Fig. 1. The progressive increase in operating temperature was due to an increase in contact film resistance that was produced purely by an ambient heat not much higher than might be experienced in actual service.

The graph of Fig. 2 shows that the contact resistance between a pair of silver bars increases with the development of silver sulphide films by successive five-minute immersions of the bars in a K_2SO_3 solution. The graph of Fig. 3 shows the high resistance of silver sulphide films at ordinary temperatures.

The present invention proposes the manufacture of disconnecting switches with contacts of different metals on which atmospheric conditions develop individually high-resistance films which, when in electrical contact and transmitting electric current, produce a condition that is conducive to electrical transfer. The most desirable form at present determined after extensive experimentation to accomplish the desired result is the use of silver to engage with copper contacts. Atmospheric and temperature conditions produce copper oxide on the copper contacts and silver sulphide on the silver contacts.

Experiments made with disconnecting switches in which the rated current traversed pre-formed films of silver sulphide and copper oxide in intimate electrical contact have produced very interesting and non-predictable results. It was found that the films are subject to electro-chemical change and that the initially high contact resistance collapsed to substantially the contact resistance of clean metallic copper-to-silver contacts. The drop in resistance is apparently due to the formation of metallic paths through the oxide and sulphide films through electro-chemical action that resulted from the momentary temperature rise produced by localized concentrations of current through the high resistance films.

The phenomenon is found to take place when current of the magnitude traversing disconnecting switches, i. e. of the order from a hundred to thousands of amperes, flows through contacting films of silver sulphide and of cupric oxide. The practical result of this phenomenon in disconnecting switch performance is well exemplified in the Fig. 4 graph which shows the relation between the operating temperature of a 2500 ampere disconnecting switch of the silver button-copper surface type and the number of periods, of five days each, that the switch was kept in an oven maintained at a temperature of 100° C. and high humidity. The contact resistance was slightly greater after the first period in the oven, but no further increase in contact resistance resulted from subsequent periods in the oven. The resistance change is indicated in terms of the temperature rise of the disconnecting switch above the ambient temperature when carrying full load, and a comparison of Figs. 1 and 4 shows that the contact resistance of the disconnect switch with silver-to-copper contacts never rises to the contact resistance that resulted from a single treatment in the oven of a copper-to-copper contact type of disconnecting switch of the same current rating. The characteristic curves of Figs. 1 and 4 show that the contact resistance of disconnecting switches with copper-to-copper contacts increased progressively with film formation on the contacts, and that the contact resistance of a disconnecting switch embodying this invention remains constant after an initial rise of negligible magnitude.

It is obviously impossible to observe the progressive steps in the automatic break-down of the high resistance of the copper oxide and silver sulphide films that may be present on the silver-copper contact surfaces when the disconnecting switch is closed, or which may develop thereon during use of the switch, but a study of the novel phenomenon indicates that the following actions take place when the high resistance films are present on the base metals of the switch. The current is not uniformly distributed over the whole apparently-contacting areas but is heavily concentrated at a few spots of very small area, thus resulting in highly localized and intense heating at the current-carrying spots. The silver sulphide melts when the temperature of the locally heated spots reaches about 850° C. and forms an electrolyte that penetrates the porous copper oxide film, thus creating a number of microscopic "molten bath" electrolytic cells in which silver-copper alloy stringers or bridges are produced. The locations of the "hot spots" of heavy current concentration may shift from time to time while the disconnecting switch is in service but any shift of current concentration to a filmed region of high contact resistance results in a repetition of the described sequence of intense local heating and conductive stringer formation.

The stated theory of operation may not be entirely accurate but it is a fact that the phenomenon of substantially constant, relatively low contact resistance is observed in disconnecting switches with cooperating contacts of silver and of copper that carry the usual power line currents of the order of 100 amperes and upward, and that tests with currents of lesser magnitude, i. e. of an order of substantially less than 100 amperes, will not effect a break-down of the high resistance of such filmed silver-copper contacts.

A typical embodiment of the invention, as shown in Fig. 5, comprises copper switch blades A provided with silver rivets B that present rounded contact surfaces for engagement with the copper jaw terminal C, and with silver rings D for engagement with the copper hinge terminal E. Each ring D is preferably secured to its blade by cutting a circular groove in the blade, inserting a pre-formed silver ring in the groove, and die-pressing the ring to embed the silver into the copper and to impart a rounded surface to the outer face of the ring. The rounded contact surfaces of the silver rivets B and rings D are pressed into firm engagement with the cooperating flat surfaces of the copper terminals C, E, by spring washers F and bolts G, the bolt at the hinge end serving as the pivotal support for the blade. The contact engagement is restricted to the order of not substantially more than line contact and the contact pressure, per unit area, is relatively high.

The surfaces of the silver contacts are hardened by the stamping operations employed in securing them to the blades, and the relative sliding movement of the silver and copper contact surfaces does not result in a cutting or scratching of either surface. The contacting surfaces engage under

a high unit pressure, and the mechanical stability of the silver contacts is believed to be due, in part at least, to the pressure-hardening of the surfaces and to the relatively large mass of silver, as distinguished from a mere film thickness, that underlies the contact surface. The mechanical aspects of such a construction are almost ideal as the wearing qualities are excellent and the friction ratio of the two metals is extremely low so that the minimum of opening effort is required.

It is to be understood that the terms "silver" and "copper" are not intended to designate merely the pure metal but to include metallic compositions consisting essentially of silver and copper respectively.

While it is preferable to form the silver contacts in the manner described, it will be readily appreciated that other structures may be adopted without departing from the essential principles of this invention.

I claim:

1. A disconnecting switch for power line service and of the type including a movable blade element, a stationary element, cooperating contact means on said elements for restricting the contact engagement of said elements to the order of not substantially more than line contact, and spring means for establishing a high pressure engagement per unit area of the cooperating contact means; characterized by the fact that surfaces of said contact means are of silver and of copper respectively.

2. A disconnecting switch for power line service and of the type including a pair of terminal elements and a blade element movable into and out of a switch-closed position in which it bridges across the terminal elements, and means restricting the current-carrying engagements of said blade element with each of said terminal elements to small surface areas held in contact under heavy unit pressure; characterized by the fact that each pair of engaged current-carrying surfaces consists of silver and of copper respectively.

3. In a disconnecting switch for power line service, a movable blade element and a cooperating stationary terminal element, said elements being of copper, and a silver contact carried by one of said elements and having a silver contact surface projecting beyond the associated element to engage a cooperating contact surface of copper on the other element.

4. In a disconnecting switch, the invention as recited in claim 3, wherein said terminal element is a hinge element on which said blade element is pivotally supported for angular movement, and said silver contact is a ring of silver surrounding the pivotal axis of the blade element and die-pressed into a circular groove cut in the face of its supporting element.

5. In a disconnecting switch, the invention as recited in claim 3, wherein said terminal element is a hinge element on which said blade element is pivotally supported for angular movement, and said silver contact is a ring of silver surrounding the pivotal axis of the blade element and die-pressed into a circular groove cut in the face of the blade element.

6. In a disconnecting switch for power line service, a blade element, a terminal element, and means pivotally supporting said blade element for angular movement into and out of engagement with said terminal element, said elements being of copper, and a silver contact carried by one of said elements and having a contact surface projecting beyond the associated element to engage a cooperating contact surface of copper on the other element.

7. In a disconnecting switch, the invention as recited in claim 6, wherein said silver contact is a silver rivet having a rounded pressure-worked contact surface.

8. In a disconnecting switch, the invention as recited in claim 6, wherein said silver contact is a silver rivet secured to said blade element and having a rounded pressure-worked contact surface.

9. In a disconnecting switch, a blade element pivotally supported on a hinge terminal member for angular movement into and out of engagement with a jaw terminal element, said elements being of a metal upon which films of copper oxide form, and means restricting the contact engagement of said elements to the order of not substantially more than line contact; said means comprising a rounded contact surface of silver on one of said elements and projecting therefrom to engage the other element.

10. In a disconnecting switch, a blade element pivotally supported on a hinge terminal member for angular movement into and out of engagement with a jaw terminal element, said elements being of a metal upon which films of copper oxide form, and means restricting the contact engagement of said elements to the order of not substantially more than line contact; said means comprising a silver contact carried by one of said elements and having a rounded pressure-worked surface projecting therefrom to engage the other element.

11. A disconnecting switch of the type including a blade element pivotally supported on a hinge element for movement into and out of engagement with a second terminal element, and a set of cooperating rounded and plane contact surfaces for limiting the engagement of said blade element with one of the other elements to not more than substantially line contact; characterized by the fact that the cooperating contact surfaces of said set comprise metals upon which atmospheric conditions form films of copper oxide and of silver sulphide respectively.

12. A disconnecting switch as recited in claim 11, wherein said blade element carries silver contacts with projecting rounded surfaces for engagement with plane contact surfaces of copper on the other elements.

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