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DIRECT CURRENT ELECTRIC SWITCHING CONTACTS

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This invention relates to electric switching contacts for use with direct current, and more particularly to contacts for relays and voltage regulators.

The life of such contacts is limited principally by the wear that is caused by the electric current. A part of the wear is produced by the heat generated during opening of the contacts before their final separation. This wear normally consists of transfer of contact material from the anode to the cathode, which is usually called bridge transfer. Another, usually greater, part of the wear is produced by the electric arc that generally is formed while the contacts are separating or closing. The arc can be avoided by keeping the voltage during contact opening and closing smaller than the minimum arc voltage, such as by using a low electromotive force and a semi-conducting voltage limiter parallel to the contacts. However, it often is not desirable or possible to so limit the voltage for the purpose of avoiding an arc.

It is among the objects of this invention to provide electric switching relay contacts which will not wear appreciably from material transfer when the contacts are opened or closed.

We have discovered that the bridge transfer that is associated with cases of no arc can be substantially eliminated by making the anode contact from a mixture of 20 to 70% silver but preferably not over 40%, 2 to 8% nickel but preferably about 5%, and the balance gold. All percentages are by weight. The material can be an alloy or a mixture of powders that has been subjected to pressure and sintered. There is practically no transfer from such an anode, and since there is no transfer anyway from the cathode when there is no arc, practically all transfer of material between the contacts is avoided.

In case arcing occurs between opening contacts, different kinds of material transfer appear. As long as the arc is very short, which means that its length remains of the order of the length of the region of the cathode drop (in voltage), about 10^{-4} cm., the anode is bombarded by high speed primary electrons that produce a dominating anodic evaporation and thus transfer of contact material from anode to cathode. We have found, in such a case also, that the anode will transfer less if it is made of a proper material in accordance with our invention. The preferred material for this purpose is the gold-silver-nickel alloy or mixture mentioned in the preceding paragraph. The same short arc can ignite as the contacts close, but its lifetime is very short and its effect usually negligible.

However, when a short arc between opening contacts lives its maximum time; that is, until the arc begins to grow out beyond the cathode region, the material transfer which it produces from the anode may be disturbing with any anode material. Fortunately, such transfer can be more or less balanced by transfer of contact material in the opposite direction, which occurs during the continued widening of the gap and the accompanying longer arc. To be more specific, this longer arc will, in front of the anode, contain a plasma, which is a highly ionized

region where the electrons are slowed down. Bombardment of the anode by these slow electrons causes only little evaporation. Simultaneously, bombardment of the cathode by positive ions will cause evaporation of the cathode to predominate, thereby resulting in a transfer of material from the cathode. This effect can return to the anode the material which was removed from it during the earlier stage of the arc. Of course, a balance is realized only when the same volume of contact material is moved in both directions.

In practice, it is difficult and usually impossible to achieve exact balance of transfer by choice of circuit, particularly when the circuit has to operate at varying currents. Yet, in accordance with our invention, the balance can be improved appreciably by using the correct contact materials, as will be explained presently. These contact materials, when used as anodes, promote an anode drop (in voltage) in the arc between the separating contacts when the current surmounts a certain limit which is characteristic for the anode material being used. The anode drop accelerates the current-carrying electrons so that they bombard the anode at high velocity, resulting in diminished transfer of cathode material to the anode, and even in an anode loss in some cases. The appearance of the anode drop sets a limit to the increase in transfer of material from the cathode when the current increases. On the other hand, weakening of the anode drop if the current would start to decrease, means a strengthening of the transfer from the cathode, which in this case is necessary for preserving the balance between the transfers from the anode and from the cathode.

In other words, suppose that balance of material transfer is achieved at a certain current with a specific anode drop, but that the current then begins to increase. In such a case an arc with an unchanged anode drop would increase the material transfer from the cathode, thereby impairing the balance. On the other hand, an anode material according to our invention would enhance the anode drop and thus limit the transfer to the anode and preserve the balance.

Since different circuit conditions require the anode drop to become effective at different current intensities, it is important to have a choice of contact materials with different current limits for the anode drop.

An anode contact made of between 1 and 10% lead (preferably about 2%) and the balance silver or any noble metal, such as gold, shows the anode drop effect at relatively high currents. By adding cadmium to this material, the anode drop will be promoted at a smaller current. The maximum amount of cadmium that the contact should contain is a percentage that would not cause the contact to oxidize too much, as that would insulate a pair of cooperating contacts from each other at the low currents and light pressures that are inherent with voltage regulators and other relays. In many special cases not over about 5% cadmium should be used. Instead of cadmium, other elements that can be added in about the same amount and that have proved to be efficient are bismuth, antimony, manganese and chromium. Any one, or a mixture of two or more of these elements, can be added. We have found that these contact materials work most satisfactorily when lead is present; otherwise, the anode drop effect is weak.

It is not necessary, however, that the anode contact be made of the anode-drop-promoting materials described in the preceding paragraph, even though anode drop is promoted by material evaporated into the arc from an anode. It is usually satisfactory to make the cathode contact of such material, and the anode of a material that does not promote an anode drop. In such a situation a transfer of material from the cathode may dominate during an initial series of switching operations. This results

in a deposit of the anode drop promoting material on the anode contact, and this deposit procures the desired anode drop as long as it covers the anode, the same as if the anode were made of the deposited material. It may be that balance then is established. However, if the deposit is moved back to the cathode by a transfer that is reversed by the anode drop, such transfer would stop again when the original anode material is uncovered, and a new deposit on the anode would then follow. Thus, in the long run, a reasonable balance is obtained.

Another advantage of using cadmium, bismuth, antimony, manganese or chromium in contacts is that the material which is transferred does not tend to concentrate in sharp peaks that may disturb the operation of the contacts, but spreads out over a relatively large area.

Although we have explained the influence of certain additive elements in electric contact materials in terms of anode drop, we wish to emphasize that our invention does not depend upon the correctness of this explanation. The fact remains that the contact materials concerned diminish or even reverse the transfer of material from cathode to the anode and that the balance of the material transfer is particularly good when the cathode is made of the anode-drop-promoting material and the anode made of another material.

According to the provisions of the patent statutes, we have explained the principle of our invention and have illustrated and described what we now consider to represent its best embodiment. However, we desire to have it understood that, within the scope of the appended claims, the invention may be practiced otherwise than as specifically illustrated and described.

We claim:

1. A cooperating pair of electric relay contacts for use with voltage regulators and the like utilizing low direct current that may form an arc when the contacts are separated, in which at least one of the contacts is formed from an electrically conducting material including up to about 5% of material selected from the group of elements consisting of cadmium, bismuth, antimony, manganese and chromium, the amount of said last-mentioned material being great enough to promote an anode voltage drop in said arc when the intensity of said current reaches a predetermined value, and the balance noble metal.

2. A cooperating pair of electric relay contacts for use with voltage regulators and the like utilizing low direct current, in which the cathode contact is formed from 1% to about 10% lead, less than 8% of material selected from the group of elements consisting of cadmium, bismuth, antimony, manganese and chromium, and the balance noble metal.

3. A cooperating pair of electric relay contacts for use with voltage regulators and the like utilizing low direct current, in which the cathode contact is formed from 1% to about 2% lead, 0.5% to 5% cadmium and the balance silver.

4. A cooperating pair of electric relay contacts for use with voltage regulators and the like utilizing low direct current that may form an arc when the contacts are separated, in which the cathode contact is formed from between 1% and 10% lead and not over about 5% of an element that will promote an anode voltage drop in said arc at a lower current than would be promoted by the cathode without said element and the balance noble metal, and the anode is formed from a material that is substantially free of anode voltage drop promotion in the current region concerned.

5. A cooperating pair of electric relay contacts for use with voltage regulators and the like utilizing low direct current that may form an arc when the contacts are separated, in which the anode contact is formed from about 5% nickel, 20 to 75% silver and the balance gold, and the cathode contact is formed from 1 to 10% lead, from about 0.5% to 5% of material selected from the group of elements consisting of cadmium, bismuth, antimony, manganese and chromium, and the balance noble metal, whereby there will be substantially no transfer of contact material from anode to cathode if no arc or only a very short arc is formed, and whereby if the arc becomes longer the initial small transfer of contact material from anode to cathode will be substantially balanced by a small transfer of contact material from cathode to anode.

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