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This invention is concerned with electrical contacts for making and breaking direct current and particularly with electrical contacts for circuit breaker mechanisms in voltage regulators and the like. The invention provides an improved contact combination comprising an anode and a cooperating cathode which do not form pronounced local spires and matching craters that tend to cause sticking of the contact mechanism.

The amount and direction of material transfer between contacts adapted to make and break direct current circuits are dependent upon the volatility of the contact material and also upon the transient electrical current and voltage conditions during the make and break. Contact materials which are entirely satisfactory under one set of electrical conditions behave in a very different manner in another set. Thus contacts which will operate for long periods under a relatively low circuit load will fail in a short period if the load is increased, and contacts of a different material may perform satisfactorily at high circuit load but fail at lower loads. For example, a voltage regulator mechanism provided with a circuit breaker in which both the cathode contact and the anode contact were made of an alloy containing 97% silver and 3% platinum failed by sticking within a period of about 6 hours when the voltage regulator was adjusted so as to interrupt a generator field current of 1 ampere about 25 times per second using a 38 ohm resistor across the contacts. Under these conditions a maximum transient voltage of about 38 volts appeared across the contacts each time they were open. Examination showed that under these conditions there was a transfer from anode to cathode which formed pronounced local spires on the cathode with matching craters on the anode. The amplitude of vibrations of the contact mechanism was of the order of .0005 inch. The spires formed were of the order of .005 inch high, and brought about failure of the contact through interlocking and sticking.

The foregoing test was repeated with the same apparatus except that new contacts of 97% silver and 3% platinum were employed and the load on the generator was increased to a point where the contacts interrupted about 1.5 amperes with a maximum transient voltage of about 57 volts. Under these conditions, the contacts acted to a greater degree than in the former test but the direction of material transfer was reversed, i. e., from cathode to anode. Moreover, in the transfer from cathode to anode the formation of sharp spires and craters did not occur, the material

transferred being spread over a broader area. Under these conditions, the contacts operated for several hundred hours without sticking and the only factor which limited their useful period of operation was wear, with its resultant change in contact adjustment and drift in regulator terminal voltage.

I have discovered that the desirable type of transfer just described which occurs with high load employing silver-platinum contacts can be produced at lower generator loads through use of a new contact combination. Thus, I have discovered that if a cathode contact of fine silver or of silver alloyed with up to 30% of metal of platinum or palladium (hereinafter referred to as the "platinum group") is employed with an anode of silver alloyed with copper, gold, tin, or mercury in substantial proportions up to about 30%, the metal transferred during make and break of the contacts is from cathode to anode and is spread out over a broad area without the formation of spires and craters, and that this effect is produced even at low voltage. For example, an anode of 95% silver and 5% mercury working with a cathode of fine silver will produce the desired dispersed type of metal transfer from cathode to anode when breaking less than 1 ampere of field current at transient voltages as low as about 19 volts.

In order to obtain (under a variety of load conditions) the desirable dispersed transfer of metal from cathode contact to anode contact without the formation of local spires and matching craters, the preferred cathode and anode compositions are, in general, as follows:

A. Cathode contact (negative).

1. Fine silver or
2. Silver alloyed with a platinum group metal in substantial proportions up to 30%.

B. Anode contact (positive).

Binary alloys of silver with substantial proportions of—

1. Copper up to 20%.
2. Gold up to 30%.
3. Tin up to 10%.
4. Mercury up to 20%.

With such anode-cathode combinations, the transfer of metal is not only of the desirable dispersed type and in the direction from cathode to anode, but is small in amount. This is probably because both contacts take on the characteristics of the cathode contact once a small amount of the cathode material has been depos-

ited on the anode, so that under the particular electrical conditions described above there is a tendency for metal to transfer from anode to cathode. The practical result of this tendency is that over a relatively wide range of field current there will be but a slight net transfer of metal from cathode to anode, even for periods of operation up to 1000 hours.

The optimum anode composition will depend, at least to some extent, upon the electrical conditions in the circuit in which it is employed with the required cathode of silver or silver-platinum group alloy, but will be within the limits specified above for substantially any commercial application of contacts to the make and break of direct current. To take a specific set of operating conditions (namely, 1 ampere field current interrupted about 25 times per second, contact shunt resistance 38 ohms) preferred anode compositions are Ag plus about 10% Cu, Ag plus about 30% Au, Ag plus about 5% Sn or Ag plus about 5% Hg.

In some instances the anode alloys may be diluted advantageously with cheaper metals. Thus, if the anode contains in excess of 2% of gold, tin or mercury (for example silver alloys with 2 to 3% gold or 2 to 10% tin or 2 to 20% mercury) it is possible to incorporate 2 to 23% of copper or cadmium or both without deleteriously influencing the behaviour of the anode-cathode combination. To be more specific, an anode of 85% silver alloyed with 5% tin and 10% cadmium will produce the same type of metal transfer when employed with a silver or silver-platinum cathode as an anode containing about 94% silver and 6% tin, i. e., the same alloy except that the cadmium diluent is omitted.

It will be observed that the polarity of the contact combination of my invention is specified in all instances. If the polarity is reversed the advantages of the contact combination are lost and at light load there will be a transfer of metal from anode to cathode to form pronounced needle-like spires on the cathode with matching holes on the anode. This type of metal transfer causes the contacts to fail by sticking or interlocking after a few hours of operation.

I claim:

1. A contact combination for making and breaking direct current which comprises a cathode selected from the group consisting of silver and silver alloys containing metal of the platinum group in proportions up to 30% and a cooperating anode of silver alloyed with a metal selected from the group consisting of copper, gold, mercury and tin in substantial proportions but not exceeding 30%.

2. A contact combination for making and breaking direct current which comprises a cathode selected from the group consisting of silver and silver alloys containing up to 30% of metal of the platinum group and a cooperating anode

of silver alloyed with tin in substantial proportions up to 10%.

3. A contact combination for making and breaking direct current which comprises a cathode selected from the group consisting of silver and silver alloys containing up to 30% of metal of the platinum group and a cooperating anode of silver alloyed with copper in substantial proportions up to 20%.

4. A contact combination for making and breaking direct current which comprises a cathode selected from the group consisting of silver and silver alloys containing up to 30% of metal of the platinum group and a cooperating anode of silver alloyed with gold in substantial proportions up to 30%.

5. A contact combination for making and breaking direct current which comprises a cathode selected from the group consisting of silver and silver alloys containing up to 30% of metal of the platinum group and a cooperating anode of silver alloyed with mercury in substantial proportions up to 20%.

6. A contact combination for making and breaking direct current which comprises a cathode selected from the group consisting of silver and silver alloys containing up to 30% of metal of the platinum group and a cooperating anode of silver alloyed with tin in proportions ranging from 2 to 10% and with 2 to 23% of metal selected from the group consisting of copper and cadmium.

7. A contact combination for making and breaking direct current which comprises a cathode selected from the group consisting of silver and silver alloys containing up to 30% of metal of the platinum group and a cooperating anode of silver alloyed with gold in proportions ranging from 2 to 30% and with 2 to 23% of metal selected from the group consisting of copper and cadmium.

8. A contact combination for making and breaking direct current which comprises a cathode selected from the group consisting of silver and silver alloys containing up to 30% of metal of the platinum group and a cooperating anode of silver alloyed with mercury in proportions ranging from 2 to 20% and with 2 to 23% of metal selected from the group consisting of copper and cadmium.

9. A contact combination for making and breaking direct current which comprises a cathode selected from the group consisting of silver and silver alloys containing up to 30% of metal of the platinum group and a cooperating anode of silver alloyed with a metal selected from the group consisting of gold, mercury and tin in substantial proportions not exceeding 30% and with from 2% to 23% of a diluent from the group consisting of copper and cadmium.

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