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(54) Benævnelse: **KONTAKTBØRSTE**

(56) Fremdragne publikationer:

EP-A1- 1 351 348
WO-A1-2012/117190
CH-A- 229 890
DE-A1- 1 926 203
DE-A1- 4 430 745
DE-A1- 10 359 896
DE-A1-102008 059 478
DE-B- 1 215 938
DE-U1- 20 300 905
FR-A- 881 871
FR-A1- 2 972 082
GB-A- 2 443 808
US-A1- 2003 127 941
Carbex: "W5N", , 19 April 2017 (2017-04-19), XP055512974, Retrieved from the Internet: URL:https://carbonbrushsolution.com/wp-con tent/pdf_datablad/w5n.pdf
Carbex: "Max speed Max current Copper graphite Characteristics", , 19 September 2018 (2018-09-19), XP055512993, Retrieved from the Internet: URL:http://www.carbex.fi/v2/fi_products/Me talligrafiittiharjat/Metalgraphite.pdf

Fortsættes ...

Anonymous: "Conductivity Of Metals Sorted By Resistivity | Eddy Current Technology", , 1 January 2016 (2016-01-01), XP055429462, Retrieved from the Internet: URL:http ://eddy-current.com/conductivity-o f-metals-sorted-by-resistivity/
EP-A1- 1 713 148
FR-A1- 2 003 341
GB-A- 2 247 232
JP-A- 5 277 762
JP-A- 10 023 717
JP-A- 61 121 744
JP-A- 2000 197 315
US-A- 3 274 304
US-A1- 2005 212 376

CONTACT BRUSH

The invention refers to the field of brushes designed for ensuring electrical contact between a fixed part / component and a rotating part / component in a rotating electric machine. This rotating part can be, for instance, part of the commutator of an electric motor or the brush of a wind turbine generator.

Generally, these brushes are made of graphite. In particular, for applications corresponding to high current, or to precise signals, there is a known art of manufacturing brushes from a mixture of graphite and silver powders.

Silver endows sliding electric contacts with a relatively small voltage drop on contact with the rotating part and low electrical resistivity, improving the dissipation of heat. In addition, during operation, silver oxides are formed with the particularity of being good electrical conductors (compared to other metal oxides). Thanks to these properties, the materials allowing a sliding electrical contact, like brushes, are advantageous and implemented more particularly in the aeronautical or wind turbine fields, when operating under extreme conditions (corrosive, hot, wet atmospheres or in partial vacuum). Accordingly, it is normally ensured that the silver component of these materials is free of metal impurities which could alter the qualities and performances by undesirable oxidization or the loss of electrical properties. However, it is well known that electrical contact materials, especially brushes, containing a metal other than silver, such as copper, are used for different purposes than those of silver-based brushes.

Nevertheless, silver is a relatively expensive raw material which is barely available on the market. In addition, it has been found that the properties of the brush depend relatively closely on the quality of the silver powder used.

The document US-A-2005/0212376 describes a brush comprising mainly carbon and silver.

Accordingly, there is a need for a sliding electrical contact material, like a brush, that is cheaper, and for which reproducibility is improved.

A brush is proposed according to claim 1, designed to ensure electrical contact between a fixed part and a moving part of an electric machine for transferring power, which brush includes a layer comprising essentially carbon, silver and another metal other than silver.

Carbon refers to any compound actually containing carbon, advantageously graphite which is the carbon having both electrical properties and friction properties suited to use as sliding electrical contacts.

Accordingly, this brush is less costly than the brushes of the prior art and the procurements of silver plays a less determining role for the properties of the brush than in the prior art for which, in the event of procurement difficulties from a given supplier, and the choice of another supplier, there is a risk of the brush properties not being reproducible.

Advantageously, the other metal, other than silver, is liable to replace it partially, while respecting on the one hand the physical properties of the component material of the brush, governing the functional performances of the brushes and, on the other, while limiting the cost of the final brush material. In particular, the nature of the other metal, the relative proportion by weight of silver/other metal and/or the sintering temperature during the manufacturing of the brushes, govern the electrical and mechanical properties, whether these metals are alloy or non-alloy metals. For instance, some metals either oxidise excessively, or do not have the desired electrical resistivity properties. In other words, the other metal is chosen so that the brush offers at least the same electrical and mechanical properties as a brush comprising essentially silver and carbon.

In other advantageous embodiments of the invention, the other metal is chosen from the group including conductive metals having typically electrical resistivity values included between 1.7 and 700 $x10^{-8}$ Ohm.m, at 20°C.

There advantageously and in a non-limiting manner, this other metal can be chosen between aluminium, zinc, iron, nickel, steel, tin and copper.

In particular, this other metal can be copper. The pruner re-experiments performed by the Applicant on the silver-copper mixture actually reveal that this mixture makes it possible to preserve and even improve the mechanical and electrical properties. In addition, the use of silver and copper in a brush ensures better compliance with the surface condition of the rotating part compared to silver on its own.

In a highly advantageous manner, the silver and the other metal are not alloyed.

Under these conditions, analysis of the microstructure of the materials obtained from a carbon, silver and copper mixture confirms that during the manufacturing of the material, according to these preferred embodiments, the copper does not form an alloy with the silver. This can be explained by a sintering temperature less than that of the silver-copper eutectic temperature (779°C). This absence of an alloy makes it possible to use the more advantageous properties of each of the metals. For instance, silver is known to be less ductile than copper but copper offers greater tenacity than silver.

In addition, an analysis of the microstructure demonstrates that the material obtained by partially replacing silver with copper produces a particularly fine metallic grid interconnected with respect to a material comprising silver metal alone, in other words, providing better percolation in the component material of the brush which is beneficial for the conducting of electric current.

This difference can be explained by the initial properties of the silver and copper grains, their respective high ductility and the specific chemical affinity of these two metals. The morphology, size, density and ductility of the grains are due to both the chemical nature of the material of the components and the method by which they are obtained. These aspects determine the utilization properties of the mixtures through their behaviour during pouring, filling, rearrangement, compressibility and compacting capability. This behaviour has a considerable influence on the densification of the said material during the compression phase. Furthermore, for ductile materials, the final properties of the said material after the sintering stage depend on this densification.

Advantageously, and on the basis of the previous observations based on the silver-copper mixture, the Applicant has selected some of the aforementioned parameters, such as the chemical nature, the packed density, the distribution of the particle size and the specific surface area of each powder to produce a material including silver and the other metal, having an optimal densification factor during the compression phase. This makes it possible to obtain a material after sintering with similar mechanical and electrical performances, or even superior, than those of the materials in which the metal is silver alone, because of the specific nature of the microstructure obtained. This selection is made more particularly on the basis of the properties of the various powders.

In other embodiments, the silver and the other metal are alloys, as long as the desired and previously mentioned effects are obtained.

Advantageously, the brush also includes an additional layer making it possible to adapt to the brush for the best to the various manufacturing and use demands.

For instance, the additional layer may not contain silver, or may include a relatively small quantity of silver, for instance less than 5% by weight. Limiting the quantity of silver in the brush again, in this way, can lead to a decreased price and dependency on the quality of silver as a raw material.

For instance, it may be planned to use the layer described above with carbon, silver and the other metal, as a wear layer, in contact with a rotating part while the additional layer forms an anchoring or connection layer ensuring electrical connection to the fixed part. In this way, we can benefit from the properties that silver offers to sliding contacts, in particular a relatively low voltage drop on contact. In this case, the additional layer is situated above the wear layer, in a vertical axis with respect to the contact plane of the brush/rotating part. The size of this layer is chosen by the man of the art with respect to the investigated brush plane. In one embodiment, the brush may include more than two layers, for instance three or more layers. In addition to a wear layer and a connecting layer, the brush can also include a switching layer, a lapping layer for lapping a commutator, or another layer. Advantageously, one or several intermediate layers between the wear layer and the connection layer can form a weight proportionate gradient for the other metal in the brush forming a layer increasing from the wear layer to the connecting layer and providing better mechanical cohesion within the brush.

Therefore, the invention is not limited by the number of layers or by their arrangement.

In particular, the brush can comprise a single silver layer as described above.

The invention is not limited by the composition of the additional layer. This layer can comprise, for instance, essentially metal, for instance, copper.

Advantageously, the additional layer can comprise essentially carbon and metal, advantageously the other metal. The use of the same metal, known as the other metal, from one layer to another, provides relatively satisfactory mechanical and electrical qualities but, naturally, there is nothing to prevent a third metal being chosen for this additional layer.

In addition to carbon and metal, the layer can comprise at least one binder and/or at least one additive in the customary proportions to the man of the art, their reading from 1 to 20% by weight, with the binder typically comprising a phenol type resin and additives chosen in particular from the solid, abrasive lubricant families and from the antioxidant additives normally used in the field of sliding electrical contacts. Advantageously, the composition of the additional layer may be similar to the layer described above in that the proportions by weight of metal and carbon can be relatively similar, from one layer to the next. The additional layer, in particular, may have a metal proportion substantially identical to the metal proportion (that is the silver and other metal assembly) of the silver layer described above.

Advantageously, in the brush comprising the additional layer and the wear layer, comprising silver and the other metal, the said layers also comprise at least one binder and at least one additive, such as carbon, the said at least one binder and/or the said at least one additive being of an identical nature and in relative proportions by weight substantially equal from one layer to the next. Accordingly, for these two layers, the same binder or binders or the same additives or additives are used, and, for instance, the same graphite, and in the proportions substantially equal from one layer to the next.

The term substantially identical refers to the difference between the proportions by weight of the carbon in one layer and the other representing less than 5% of the weight of carbon in the wear layer or the anchoring layer, and advantageously less than 2%. Indeed, this composition allows better mechanical cohesion between the two layers after firing.

This provides relatively good mechanical cohesion between these two layers and endows the brush with a relatively long life duration. Without wishing to be confined by a theory, there is the possibility of the two thermal expansion coefficients of the two layers being relatively similar, thus limiting the forming of stresses at the interface between these layers.

Within the silver layer, the relative proportions by weight of the silver and of the other metal are from advantageously from 20/80 to 80/20.

For instance, the relative proportions by way of silver metal and of the other metal are preferably 70/30 to 30/70. Advantageously, the relative proportions in silver metal and the other metal are included within a range of values extending from 40/60 to 60/40, and preferably 45/55 to 55/45, and in particular 50/50. In some cases, the relative proportions by weight of the silver and of the other metal are from 70/30, 50/50 or 30/70.

The term “layer comprising essentially such and/or such a component” means that the overall weight of this such and/or such a component represents more than 70% of the weight of the layer, advantageously more than 80% of the weight of the layer and advantageously approximately 90% of the layer. The term “approximately 90%” means between 85% and 95% and advantageously between 88 and 92%.

The remainder of the weight of the layer consists of additives and/or binders. The proportion by weight of the additive or additives can represent less than 10% of the weight of the layer, advantageously less than 5% of the weight of the layer, and advantageously more than 2% of the weight of the layer. The proportion by weight of the binder or binders can represent less than 20% of the weight of the layer, advantageously less than 10% of the weight of the layer, and advantageously more than 4% of the weight of the layer.

According to the invention, each of these such or such a component is present in the layer to more than 15% by weight with respect to the weight of the layer, advantageously to more than 20% by weight with respect to the weight of the layer and advantageously to less than 80% by weight with respect to the weight of the layer.

For instance, the weight of the silver/copper/carbon assembly may represent 90% of the weight of the wear layer and the weight of the copper alone may represent between 20% and 40% of the weight of the wear layer. For instance, the weight of the copper-graphite assembly may represent 90% of the weight of the anchoring layer.

Among the advantages of brushes made according to the invention, the following are noteworthy.

Under similar manufacturing conditions and the same test conditions, it has been observed that a silver/carbon brush, conventionally comprising 65% by weight of silver, may have a rate of wear and a friction coefficient substantially identical to those of a brush based on carbon/silver/other metal, in particular with the other metal being copper.

The Applicant has also observed better allowance for the surface condition of the rotating part, in particular less formation (out of round). Without being bound by any theory whatsoever, the Applicant assumes that obtaining a particular microstructure of the material comprising silver and another metal, which is in particular copper, could explain this, at least to some extent.

In addition, no temperature increase is observed in the rotating part with the use of the brush according to the invention which remains in the 70 to 90°C range according to the relative proportions by weight used. This observation may appear surprising because, considering that silver is a better electrical conductor than the other metal according to the invention, substituting part of the silver by this other metal could lead to an increased temperature by a Joulian effect. However, it has been observed that the electrical properties are preserved and that in addition, the metal network offers better percolation.

Accordingly, the overall (electrical and mechanical) losses are preserved.

A method of manufacturing a brush according to the invention is also proposed, comprising a stage of mixing a carbon powder, in particular graphite, with a metal powder which metal powder comprises essentially silver and another metal different from silver. This metal powder itself may have been obtained, for instance, by mixing a silver powder and a powder of this other metal.

Depending on the embodiment, the powders are then compressed, possibly in a suitable mould having the desired shape of the brush, then the raw material, that is not sintered, is then sintered at a temperature below that of the silver/ other metal eutectic temperature, leading to a non-alloy material being obtained.

The powders of the various components have similar particle sizes and are usually selected by the man of the art to obtain the desired physical characteristics of the end material.

This process is used to obtain the brush as described above.

It is also proposed to use the brush obtained for an electric machine used for power transfer, in particular for a machine which is a generator such as a wind turbine generator.

The invention is not limited by a given application. In particular, the following might be referred to:

- applications related to the transfer of electric power, for instance, in the field of wind turbine generators, special machines or other devices,

- applications in very damp atmospheres, for instance, in the aeronautical or aerospace fields.

The invention is described in greater detail with reference to an embodiment described below, referring to Figure 1 which shows an example of the microstructure of a brush wear (A) according to a prior art comprising 65% silver and graphite, (B) according to the invention, with relative proportion by weight of Ag/Cu of 50/50, also containing graphite.

In this embodiment, a brush comprising two layers, known as a dual layer brush, includes:

- a wear layer known as the silver layer, functional layer, or yet again contact layer, and

- an additional layer, also known as the connecting or anchoring layer.

The wear layer comprises essentially carbon in the form of graphite, silver and copper.

The weight of the silver in the wear layer represents almost 32% of the weight of the wear layer.

The weight of the copper in the wear layer represents almost 32% of the weight of the wear layer.

The remaining weight, that is 36% of the weight of the wear layer comprises essentially graphite and also includes one or several of the binders and additives, in the usual proportions for the man of the art. Phenol resin has been chosen as binder. For instance, graphite is contained to 26% by weight compared to the weight of the wear layer, the additive or additives to 3.5% by weight, and the phenol resin to 6.5% by weight.

The connecting layer contains essentially graphite and copper.

The weight of the copper in the copper layer represents almost 64% of the weight of the anchoring layer.

The remaining weight, that is 36% of the weight of this anchoring layer, consists essentially of graphite and may include one or several binders and additives of the types and in the usual proportions for the man of the art. For instance, the graphite appears to 26% by weight with respect to the weight of the connecting layer, the additive or additives to 3.5% by weight and the phenol resin to 6.5% by weight.

The graphite, the binders and the additives are the same from one layer to another. For instance, each of these materials can be procured from the same supplier.

It will be found that the proportion of copper by weight in the connecting layer is substantially identical to the proportion by weight of the metal (in this case, silver and copper) in the wear layer. In this example, we thus have 64% by weight of metal in one layer and the other.

In other words, the proportion by weight of the graphite, added to the binder(s) and additive(s) is substantially the same in the connecting layer and in the wear layer.

The term substantially identical refers to the difference between the proportions by weight of the carbon in one layer and the other representing less than 5% of the weight of carbon in the wear layer or the anchoring layer, and advantageously less than 2%. Indeed, this composition allows better mechanical cohesion between the two layers after firing.

The anchoring layer or connecting layer is not designed to come into contact with the rotating part during the life of the brush. Its function is to accommodate the cables or the other electrical connecting components and to the necessary electrical and mechanical properties to ensure the correct operation of the brush. This connecting layer therefore does not need to contain silver in its make-up. Therefore, this layer is made up essentially of graphite and copper. This connecting layer has the same metal proportion and the same carbon proportion as the wear layer, also known as the functional layer or contact layer.

In this embodiment, within the wear layer, the silver and copper appear in relative proportions by weight of 50/50. As an alternative, within this wear layer, a relative proportion of silver compared to the relative proportion by weight of copper can be provided for as 70/30.

In another alternative, within this wear layer, a relative proportion of silver compared to the relative proportion of copper can be provided for as 30/70.

The relative proportions by weight of 50/50 are particularly advantageous in that they allow the brush cost to be reduced by 68% compared to a brush of the prior art, comprising essentially graphite and silver. When the relative proportions by weight of silver and copper are 70/30, the cost reduction compared to the prior art is approximately 30%.

In this embodiment, a choice has been made to use copper. This metal offers the advantage of being relatively conductive. However, it is possible to consider choosing another metal, in particular, aluminium, iron, tin, steel or zinc, which may offer advantages with respect to their cost.

There follows a brief description of the manufacturing method of this brush according to a preferred embodiment of the invention.

To obtain the wear layer, it is possible to mix initially, for instance, phenyl resin with graphite. The phenol resin then coats the graphite particles. In a second stage, the graphite coated in this way is crushed and served to obtain a usual particle size distribution for the man of the art. Then this premix is mixed consistently with the silver powder, the copper powder and one or several additives.

To obtain the connecting layer, steps may be taken to mix the same premix with the copper powder.

The dual layer brush can then be produced using a process as described in document FR 2 709 611. For instance, the mixture comprising essentially copper and graphite on the one hand, and the mixture comprising essentially copper, silver and graphite on the other hand, are fed into a mould via a partition hopper, guided by a piston-type mobile base. The powders in the mould are then compressed by an upper piston using a compression force to produce the desired density then the obtained material is sintered at a temperature included between 200 and 799°C. In this way a brush is obtained comprising non-alloy metals.

The Applicant has carried out tests on an electric rotating machine with brushes comprising, as a wear layer:

Sample A: 70/30 (relative weight proportion of Ag/Cu),

Sample B: 60/40 (Ag/Cu)

Sample C; 50/50 (Ag/Cu),

Sample D: 30/70 (Ag/Cu)

Comparative sample: 100/0 (Ag/Cu)

The test conditions are as follows:

The rotating part consists of a bronze commutator ring measuring 200 mm in diameter, with its width adapted to the size of the brushes, in this precise case, 27 mm, and turning at a peripheral velocity of 20m/s.

Three identical brushes are in contact with the ring and have dimensions of t×a×r, where “t”, “a” and “r” are defined according to the nomenclature of the International Electrical Commission (Switzerland), of 20×10×32 mm. A pressure of 380 g/cm^2 is applied to the brushes and the current density is 15A/cm^2. The overall ambience of the assembly is maintained at a fixed temperature of 55°C throughout the test by means of an appropriate device. All the aforementioned parameters are retained as being typical for the targeted application.

Table 1 shows the results obtained.

Table 1

Sample	Relative weight proportion of Ag/Cu),	Percentage by weight*	Wear (mm/1000h)	Temperature (T°C)
Comparison	100/0	65% Ag / 0% Cu	2.6	81
A	70/30	45% Ag / 20% Cu	2.6	76
B	60/40	39% Ag / 26% Cu	2.1	83
C	50/50	32% Ag / 32% Cu	1.2	91
D	30/70	20% Ag / 45% Cu	1.7	77

Note: in some cases, the value of the percentages by weight have been approximated.

Table 1 shows that the brushes of the invention show not only signs of wear comparable to that obtained with conventional brushes, but that this wear may be less by a factor of 2.

Surprisingly, the surface temperature of the ring is substantially the same from one sample to the next since the measured values conform to the recommendations made by the man of the art, that is, an interval of between 60 and 100°C, to obtain the forming of the third body, known as the patina, required for optimal tribological operation of the brush/ring assembly.

Patentkrav

1. Børste beregnet til at sikre elektrisk kontakt mellem en stationær del og en bevægelig del hos en elektrisk maskine til overførsel af effekt, **kendetegnet ved at** børsten omfatter et lag hovedsageligt fremstillet af kulstof, sølv og et andet metal forskelligt fra sølv, idet kulstoffet er til stede i en andel på mere end 15 vægtprocent i forhold til lagets vægt, idet sølvet er til stede i en andel på mere end 15 vægtprocent i forhold til lagets vægt, og det andet metal forskelligt fra sølv er til stede i en andel på mere end 15 vægtprocent i forhold til lagets vægt, og **ved at** laget er opnået ved at blande et kulstofpulver og et metalpulver, hvor metalpulveret hovedsageligt består af sølv og af det andet metal forskelligt fra sølv.

2. Børste ifølge krav 1, i hvilken det andet metal er valgt således, at børsten har i det mindste de samme elektriske og mekaniske egenskaber som en børste hovedsageligt fremstillet af sølv og kulstof.

3. Børste ifølge et hvilket som helst af kravene 1 eller 2, i hvilken det andet metal er valgt fra gruppen bestående af ledende metaller med elektriske modstande mellem 1,7 og 700×10^{-8} ohm.m ved 20°C.

4. Børste ifølge et hvilket som helst af kravene 1 til 3, i hvilken det andet metal er valgt blandt aluminium, zink, jern, nikkel, stål, tin og kobber.

5. Børste ifølge et hvilket som helst af kravene 1 til 4, i hvilken sølvet og det andet metal ikke er legerede.

6. Børste ifølge et hvilket som helst af kravene 1 til 5, i hvilken de relative vægtproportioner af sølvmetal og andet metal er i området af værdier strækkende fra 30/70 til 70/30, og i særdeleshed mellem 40/60 og 60/40.

7. Børste ifølge et hvilket som helst af kravene 1 til 6, endvidere omfattende mindst et yderligere lag.

8. Børste ifølge krav 7, i hvilken det yderligere lag ikke indeholder sølv.

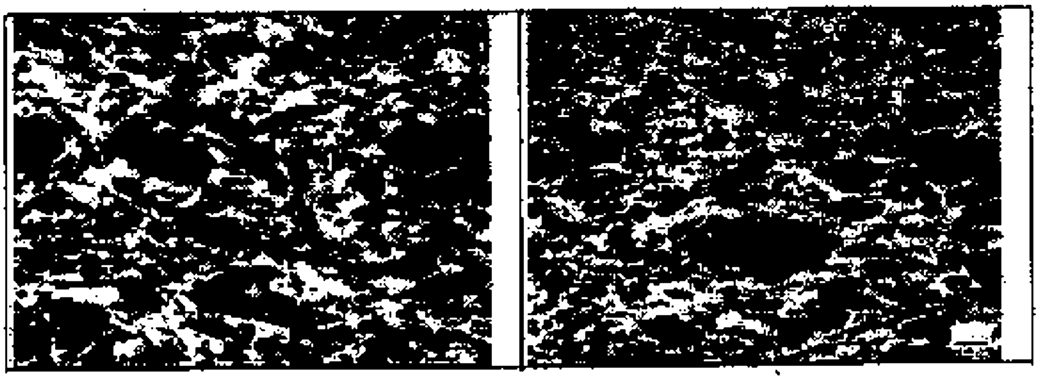
9. Børste ifølge krav 7 eller 8, i hvilken det yderligere lag hovedsageligt er fremstillet af kulstof og metal.

10. Børsten ifølge krav 9, i hvilken det yderligere lag og slidlaget, der omfatter sølv og det andet metal, endvidere omfatter mindst et bindemiddel og/eller mindst et additiv, **kendetegnet ved at** kulstoffet, det mindst ene bindemiddel og/eller det mindst ene additiv har identiske naturer og er til stede i alt væsentligt i ens relative vægtproportioner fra et lag til et andet.

11. Anvendelse af børsten ifølge et hvilket som helst af kravene 1 til 10 i en elektrisk maskine til overførsel af effekt, hvilken maskine i særdeleshed er en generator.

12. Fremgangsmåde til fremstilling af en børste som defineret ifølge et hvilket som helst af kravene 1 til 10, omfattende et trin med blanding af kulstofpulveret og metalpulveret.

13. Fremgangsmåde ifølge krav 13, i hvilken pulverne derefter komprimeres, og hvor det opnåede råmateriale derefter sintres ved en temperatur under den eutektiske temperatur for sølv/andet metal.



(A) (B)

Fig. 1