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ELECTRICAL CONTACT BRUSH

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The invention relates to electrical contact brushes, and more specifically to carbon brushes for use in electrical machinery required to operate under conditions such as exist in the atmosphere at high altitudes.

Well-made brushes composed of natural or artificial graphite, or other commercial forms of carbon, or of mixtures of carbon and one or more metals such as copper and silver, are very durable and of long life when operated in sliding contact against copper commutator bars or slip-rings at sea level or at altitudes up to about 15,000 feet. At high altitudes brush wear is substantially accelerated, and under atmospheric conditions encountered at altitudes over 25,000 feet above sea level, the rate of wear of conventional brushes is extremely rapid. For example, a standard high-quality carbon brush, when operated against a copper commutator in air at 30,000 feet, wears almost as rapidly as if it were bearing against an abrasive wheel, and instances are known where brushes have worn out completely in less than an hour at these altitudes. The most suitable of the known brush compositions may in some instances last several hours; but at best the brushes can not be relied upon for long.

Modern aircraft use electrical motors, generators, and other electrical devices requiring contact brushes. Both military and civil aircraft are being designed to operate at great altitudes, and there is an urgent demand for electrical contact brushes that will operate dependably over a useful long life at such altitudes. The principal object of this invention is to meet this demand.

The reasons for the poor behavior of brushes at high altitudes are not altogether clear; but it seems certain that two important factors are the dryness and the low oxygen pressure of the air. A similar behavior has sometimes been observed, during periods of unusually dry winter weather, even on the earth's surface in the cases of some brush compositions; but the problem has not been a serious one. By operating brushes in a test chamber in which the atmosphere can be controlled, it has been found that either a low moisture content or a low partial pressure of oxygen may cause rapid brush wear, and it has also been found that many expedients which overcome the trouble caused by dry air do not materially offset the ill effects of a low partial pressure of oxygen.

These observations suggest that an important factor in the satisfactory operation of a carbon brush at low altitudes is a film between the commutator or ring and the brush, which film is maintained by moisture and oxygen in the air. Further support for this hypothesis, and a suggestion that other film-forming materials might be substituted for moisture and oxygen, are found in the observation that new electrical apparatus, still containing traces of slightly volatile compounds in its insulation and paint, may not give trouble at high altitudes until after several weeks or months of use. This latter circumstance increases the hazard, because rapid brush wear may start without warning after a considerable period of satisfactory operation. In an airplane several hours from its base the brushes may suddenly start to wear at a rate which will destroy them in an hour.

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One approach to the problem is to impregnate the brushes with one or more substances which will establish and maintain a suitable film between the commutator or slip-ring and the carbon brush. But the choice of an impregnant material is a difficult one, for much more is involved than the mere provision of a film-forming material. The material must be effective in small amounts, because the interstitial storage space in a brush body is not very great. It must be a liquid or liquefiable by melting or by solution to make impregnation possible, and it must have ability to penetrate thoroughly both inner and outer pores of the carbon. It must not evaporate rapidly. It must not exude, for exudation may result not only in undue depletion of the impregnant but also in the formation of a surface layer which tends to pick up dirt and to interfere with the smooth operation of the brush in its holder. Finally, the film which the impregnant supplies must have a low electrical resistance, must not pick up dirt nor decompose to deleterious products, and must be stable under a wide variety of conditions of atmosphere, temperature, and of mechanical and electrical stresses. Dozens of brush impregnants, including such materials as paraffin wax, beeswax, carnauba wax, linseed oil, ethylene glycol, greases, oleic acid or sodium oleate, and calcium chloride have been proposed for use at low altitudes, but for the problem here considered prior-known impregnants have given unreliable results. In many tests of old impregnants there were a few which improved brush life under some operating conditions, but none were found which increased the life to a commercially satisfactory level under the conditions existing at altitudes above 25,000 feet, and at the same time satisfied the other requirements indicated.

In accordance with this invention I have found that certain impregnant materials, incorporated with brush compositions, meet the above specified conditions, are adapted to establish a film of lubricating characteristics at the boundary between a brush surface and the sliding or rotating parts with which it contacts, and maintain such film under atmospheric conditions low in moisture and oxygen pressure. These impregnants are composed essentially of two components, one consisting of polyoxyalkylene diols or ethers of these compounds, and the other comprising a high molecular weight aliphatic carboxylic acid, for instance the fatty acids such as oleic, palmitic and stearic, or the acids commonly known as naphthenic acids obtained from petroleum. A combination of these materials, incorporated with carbon brushes, by impregnation separately with each ingredient or with the previously mixed components, imparts a remarkable improvement in brush life and operating characteristics at high altitudes.

The polyoxyalkylene diols and their ethers, suitable for the purpose of the invention, are viscous liquids, or readily meltable wax-like solids, of a chain-like hydrocarbon structure consisting primarily of a plurality of 1,2 alkylene oxide radicals. The true diols are sometimes referred to as polyoxyalkylene glycols, and in the ether derivatives one or both of the hydroxyl hydrogens is replaced with an ether-forming radical. The diols and their monoethers are essentially addition products of the 1,2 alkylene oxides, and they can be made by reacting these oxides with substances having a hydrogen atom reactive therewith, such as water, alcohols, alkylene glycols and the like; the reaction being carried out in the presence of an alkaline catalyst, with the additive amounts of the alkylene oxide controlled to produce the molecular size desired. When the substance reacted with the alkylene oxide is water or a lower molecular weight glycol the resulting product has the diol structure, whereas a monohydroxy alcohol produces in the reaction the monoether derivatives of the polyoxyalkylene diols. In any of these reactions the final product is a complex mixture of molecules of different molecular weights depending upon the number of oxyalkylene radicals in each chain structure, but with suitable control of reaction conditions a mixture of products having molecular weights within a desired limited range, and having a desired over-all average molecular weight, can be obtained. These products will also have viscosities increasing in definite order with the average molecular weight, and either viscosity or average molecular weight, together with indication of the reacting components, have been used to further identify the exact nature of the materials.

More specifically, the products useful for the present purpose are those having an average molecular weight greater than about 250 and upward to 5,000 or more, as determined by the Menzies and Wright method described at page 2314, volume 43 (1921) of the Journal of the American Chemical Society, and in which the essential chain radicals are ethylene oxide, 1,2 propylene oxide, or mixtures of the two oxides in varying weight ratio from 25–75 to 75–25 respectively. The viscosity of such compositions may range from about 50 to over 3,000 Saybolt Universal seconds at 100° F. The monoalkyl ethers of these diols, such as the methyl, ethyl, butyl and tetradecanol ether, formed with a starting reactant of the corresponding alcohol, have also

given satisfactory results, and within the broad terms polyoxyalkylene diols and their ethers, as used herein, any of the products indicated are intended to be included.

As the acid component of the impregnant mixture, many tests have indicated that any of the higher aliphatic carboxylic acids containing from about eight to twenty-five carbon atoms, and particularly those of the generally known fatty acid class, will produce desirable results. Naphthenic acids, as recovered from petroleum, are here included within the latter class. Commercially available naphthenic acids have been identified as products composed of a mixture of many carboxylic acids of varying molecular weight, including small quantities of ordinary fatty acids with predominating amounts of cyclic aliphatic acids, particularly those of the cyclopentane series. The products are usually marketed as viscous liquids of deep to pale yellow color depending upon the purity and the total acid content, which may vary upwards from about 90%, with the balance being largely oil, sodium naphthenate and unsaponifiable matter. The acid values (mg. KOH/gm.) of commercial naphthenic acids may vary from about 165 to over 300, and those having acid numbers between 200 and 300 are of a purity suitable for the purposes of this invention. In this disclosure the term "naphthenic acids" is intended to cover all grades of these products as indicated, which are at least of ordinary commercial purity. Sodium and potassium naphthenates or other metal naphthenates may also be used in the impregnant mixture, and in fact some of these salts are often present in small amounts in the commercial products described.

As already indicated, the film-forming materials may be incorporated with the brush by separate impregnations with each component, or by a single impregnation from previously mixed solutions of the two ingredients. This can be accomplished in the usual manner under vacuum or pressure, to insure a uniform distribution and substantially complete filling of the interstitial spaces in the brush body. After removing any solvents used by a preliminary drying, the brush is given a final baking at a temperature of about 150° C. to 210° C., for a period varying inversely with the temperature from 1 to 4 or more hours. The baked residue of the combined added materials will vary in amount with the particular brush composition being treated, but usually from about 2.0% to 6.0% by weight constitutes the total amount of impregnant residue which can be incorporated, and this is well sufficient to serve the purposes intended. The relative proportions of each impregnant component may also vary, but as initially incorporated with a mixture of the two ingredients, the polyoxyalkylene diol is preferably present in predominating amounts. In the proportion of about 10 parts of the acid component to 90 parts of a polyoxyalkylene diol, excellent results have been attained.

The following examples will give further, and more specific, illustration of the invention, and show a number of representative, and satisfactory, impregnant mixtures. The essential conditions and results of each example are listed in tabular form, and include indication of the nature and composition of the impregnant, the manner of baking after impregnation, the amount of baked impregnant residue, and the life characteristics of the treated brushes. The latter value has been determined in two ways, one by means of a dummy commutator, giving

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hour per inch figures as indicated in Examples 1 and 2, and the other by operation of the brushes on a General Electric Amplidyne unit of a type now used in airplane electrical systems. Examples 3 to 7, inclusive, express brush life as determined by the second means.

The dummy commutator machine used in the first two examples has a commutator about 6½ inches in diameter, with a speed of 1500 R. P. M. While no commutation takes place in this machine, the brushes carry current and are mounted in the usual manner in sliding contact with the commutator bars. Thus total contact drop, brush life and brush friction can be readily measured, and the characteristics so determined will correlate with those obtained under actual commutation conditions. The life tests in both Examples 1 and 2 were made in dry air containing less than 3 mg. of moisture per cubic foot at atmospheric pressure, and the brush stock was a conventional grade of equal parts by weight of copper and natural graphite.

The Amplidyne is a dynamoelectrical amplifier having a motor armature and a generator armature, the former driving the unit while the generator armature supplies power in amounts varying with the field control. The generator armature has four brushes, two of which in the ordinary commutating axis are short-circuited upon themselves, while the other two at right angles form the output circuit. The life values as given in Examples 3 to 7 were obtained with intermittent loads on the Amplidyne, and with the unit operating in a closed chamber at an air pressure reduced to 19 cm. of mercury, or that corresponding to the pressure at an altitude of about 35,000 feet. The chamber was cooled to a temperature of about −40° C. or below, and dry air, with a dew point lower than −60° C., was fed into the chamber to provide fresh atmosphere throughout the test and sweep out contaminating gases and vapors.

The brushes used in all examples were of a copper–graphite stock, and the naphthenic acid was a commercially available grade, having an acid member (mg. KOH/gm.) of 286, 2.0% unsaponifiable, and a distillation range of 160°–198° C. at 6 mm. mercury pressure.

Example 1

Impregnant composition: 90 gms. polyoxyethylene diol of a viscosity about 220 Saybolt Universal seconds at 100° F.; 10 gms. naphthenic acid.
Baking schedule: 4.5 hrs. at 155° C.
Baked impregnant residue: 4.64% by weight.
Brush life—dry air, atmospheric pressure: 4,570 hrs. per inch.

Example 2

Impregnant composition: 90 gms. polyoxyethylene diol of a viscosity about 220 Saybolt Universal seconds at 100° F.; 10 gms. oleic acid.
Baking schedule: 4.5 hrs. at 160° C.
Baked impregnant residue: 4.44% by weight.
Brush life—dry air, atmospheric pressure: 4,300 hrs. per inch.

Example 3

Impregnant composition: 90 gms. polyoxyethylene diol of a viscosity about 220 Saybolt Universal seconds at 100° F.; 10 gms. naphthenic acid; 33.3 cc. water.
Baking schedule: 4.5 hrs. at 160° C.
Baked impregnant residue: 4.78% by weight.

Brush life—high altitude conditions: Motor 456 hrs. per inch; generator 792 hrs. per inch.

Example 4

Impregnant composition: 90 gms. polyoxyethylene diol of a viscosity about 220 Saybolt Universal seconds at 100° F.; 10 gms. naphthenic acid; 33.3 cc. water.
Baking schedule: 1 hr. at 220° C.
Baked impregnant residue: Motor brushes, 4.17% by weight; generator brushes, 4.20% by weight.
Brush life—high altitude conditions: Motor 308 hrs. per inch; generator 304 hrs. per inch.

Example 5

Impregnant composition: 90 gms. mono-tetradecanol ether of polyoxyalkylene diol formed of equal parts by weight of ethylene oxide and 1.2 propylene oxide, and having a viscosity of about 1100 Saybolt Universal seconds at 100° F.; 10 gms. naphthenic acid; 33.3 cc. water.
Baking schedule: 1 hr. at 200° C.
Baked impregnant residue: Motor brushes, 3.97% by weight; generator brushes, 3.77% by weight.
Brush life—high altitude conditions: Motor 1,236 hrs. per inch; generator 1,100 hrs. per inch.

Example 6

Impregnant composition: 90 gms. monobutyl ether of polyoxyalkylene diol formed of equal parts by weight of ethylene oxide and 1.2 propylene oxide, and having a viscosity of about 2117 Saybolt Universal seconds at 100° F.; 10 gms. naphthenic acid; 33.3 cc. water.
Baking schedule: 1 hr. at 200° C.
Baked impregnant residue: Motor brushes, 4.24%; generator brushes, 4.07%.
Brush life—high altitude conditions: Motor 432 hrs. per inch; generator 736 hrs. per inch.

Example 7

Impregnant composition: 90 gms. monobutyl ether of polyoxy 1.2 propylene diol of a viscosity about 100 Saybolt Universal seconds at 100° F.; 10 gms. naphthenic acid.
Baking schedule: 1 hr. at 200° C.
Baked impregnant residue: Motor brushes, 2.88%; generator brushes, 3.25%.
Brush life—high altitude conditions: Motor 148 hrs. per inch; generator 340 hrs. per inch.

The invention contemplates the treatment of brushes as indicated for all general uses in aircraft for high altitude operation. The composition of the brush stock can be varied within embodiments now customary, and where defined in the claims as a "carbonaceous body," compositions entirely of commercial forms of carbon, or of mixtures of carbon with one or more metals, are intended to be included. The preferred impregnant mixture can also be modified over the specific examples given, to suit different brushes and their particular operating requirements.

I claim:

1. Electrical contact brush comprising a carbonaceous body containing a minor proportion of an impregnant material acting to prolong the life of such brush in operation under atmospheric conditions low in moisture and oxygen pressure, said impregnant material being composed of two components, one selected from the group consisting of polyoxyalkylene diols and their ethers, and the other comprising a member of the group consisting of aliphatic carboxylic acids containing from about eight to twenty-five carbon atoms and salts of such acids.

2. Electrical contact brush comprising a carbonaceous body containing a minor proportion of an impregnant material acting to prolong the life of such brush in operation under atmospheric conditions low in moisture and oxygen pressure, said impregnant material being composed of two components, one selected from the group consisting of polyoxyalkylene diols and their ethers of a viscosity greater than about 50 Saybolt Universal seconds at 100° F., and the other comprising a member of the group consisting of oleic, stearic, palmitic and naphthenic acids.

3. Electrical contact brush comprising a carbonaceous body containing a minor proportion of an impregnant material acting to prolong the life of such brush in operation under atmospheric conditions low in moisture and oxygen pressure, said impregnant material being composed of two components, one selected from the group consisting of polyoxyalkylene diols and their ethers, and the other comprising a member of the group consisting of aliphatic carboxylic acids containing from about eight to twenty-five carbon atoms and salts of such acids, the total amount of said impregnant material being about 2.0% to 6.0% by weight of the brush.

4. Electrical contact brush comprising a carbonaceous body containing a minor proportion of an impregnant material acting to prolong the life of such brush in operation under atmospheric conditions low in moisture and oxygen pressure, said impregnant material being composed of two components, one selected from the group consisting of polyoxyalkylene diols and their ethers, and the other comprising a member of the group consisting of aliphatic carboxylic acids containing from about eight to twenty-five carbon atoms and salts of such acids, the first-mentioned impregnant component being present in predominating amount over the second component, and the total amount of said impregnant material being about 2.0% to 6.0% by weight of the brush.

5. Electrical contact brush comprising a carbonaceous body containing a minor proportion of an impregnant material acting to prolong the life of such brush in operation under atmospheric conditions low in moisture and oxygen pressure, said impregnant material being composed of the baked residue of a mixture of polyoxyethylene diol of a viscosity greater than about 50 Saybolt Universal seconds at 100° F., and naphthentic acid.

6. Electrical contact brush comprising a carbonaceous body containing a minor proportion of an impregnant material acting to prolong the life of such brush in operation under atmospheric conditions low in moisture and oxygen pressure, said impregnant material being composed of the baked residue of a mixture of polyoxyethylene diol of a viscosity greater than about 50 Saybolt Universal seconds at 100° F., and oleic acid.

7. Electrical contact brush comprising a carbonaceous body containing a minor proportion of an impregnant material acting to prolong the life of such brush in operation under atmospheric conditions low in moisture and oxygen pressure, said impregnant material being composed of the baked residue of a mixture of a monoether of polyoxyalkylene diol of a viscosity greater than about 50 Saybolt Universal seconds at 100° F., and naphthenic acid.

8. Electrical contact brush comprising a carbonaceous body containing a minor proportion of an impregnant material acting to prolong the life of such brush in operation under atmospheric conditions low in moisture and oxygen pressure, said impregnant material being composed of the baked residue of a mixture of a monoether of polyoxyalkylene diol formed from ethylene oxide and 1,2 propylene oxide in weight ratios of from 25–75 to 75–25 respectively and having a viscosity greater than about 50 Saybolt Universal seconds at 100° F., and naphthenic acid.

9. Electrical contact brush comprising a body of graphite and copper containing an impregnant material acting to prolong the life of such brush in operation under atmospheric conditions low in moisture and oxygen pressure, said impregnant material amounting to about 2.0% to 6.0% by weight of the brush, and being composed of the baked residue of a mixture of about 90 parts by weight of polyoxyethylene diol of a viscosity about 220 Saybolt Universal seconds at 100° F., and 10 parts by weight of naphthenic acid.

10. Electrical contact brush comprising a body of graphite and copper containing an impregnant material acting to prolong the life of such brush in operation under atmospheric conditions low in moisture and oxygen pressure, said impregnant material amounting to about 2.0% to 6.0% by weight of the brush, and being composed of the baked residue of a mixture of about 90 parts by weight of monotetradecanol ether of polyoxyalkylene diol formed from equal weight proportions of ethylene oxide and 1,2 propylene oxide and having a viscosity of about 1100 Saybolt Universal seconds at 100° F., and 10 parts by weight of naphthenic acid.

11. Electrical contact brush comprising a body of graphite and copper containing an impregnant material acting to prolong the life of such brush in operation under atmospheric conditions low in moisture and oxygen pressure, said impregnant material amounting to about 2.0% to 6.0% by weight of the brush, and being composed of the baked residue of a mixture of about 90 parts by weight of monobutyl ether of polyoxyalkylene diol formed from equal weight proportions of ethylene oxide and 1,2 propylene oxide and having a viscosity of about 2100 Saybolt Universal seconds at 100° F., and 10 parts by weight of naphthenic acid.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
444,794	Cook	Jan. 13, 1891
2,224,724	Elsey	Dec. 10, 1940
2,326,000	Teeple	Aug. 3, 1943
1,930,853	Kollek et al.	Oct. 17, 1933
1,847,796	Thurston	Mar. 1, 1932
1,319,129	Wells	Oct. 21, 1919
428,742	Brush	May 27, 1890