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WEAR- AND HEAT-RESISTANT MATERIAIS

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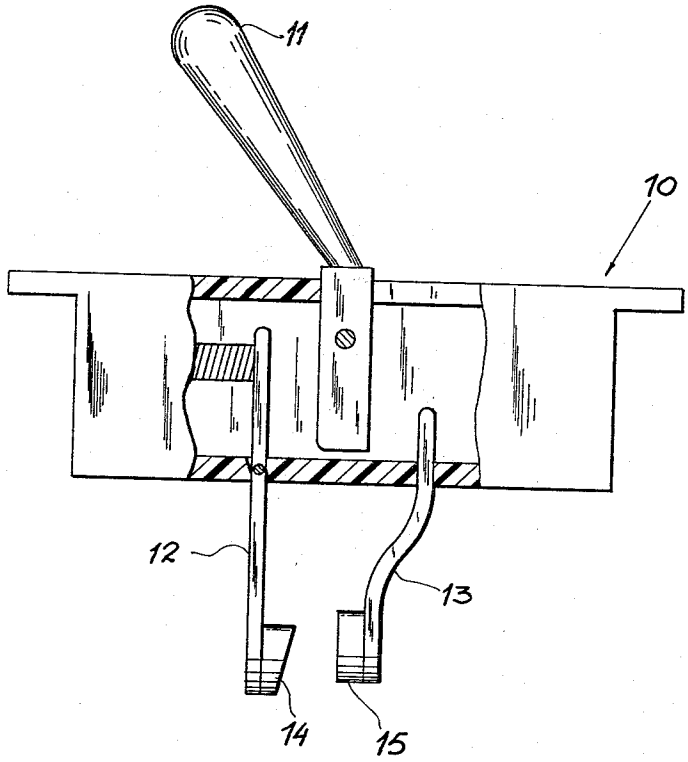

Fig. 1

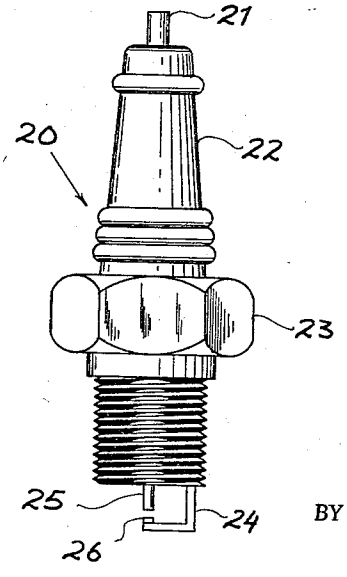

Fig. 2

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WEAR- AND HEAT-RESISTANT MATERIALS

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2 Claims. (Cl. 75—128)

My present invention relates to wear- and heat-resistant materials and especially conductive materials adapted to be incorporated in spark- or arc-discharge electrodes and/or contacts of electrical devices. This application is a continuation-in-part of my copending application Ser. No. 281,365, filed May 17, 1963.

In the aforementioned copending application, I disclose improved electrode materials, this term being used generically to define conductive substances suitable for development of spark or arc discharges and as the contact regions of switch devices, wherein the electrode system includes at least one substance having a highly electronegative character and preferably selected from Groups IVb–VIIb of the Mendeleeff Periodic Table (conventional long form) and adapted to generate highly electronegative ions and produce an ion shield adjacent the surfaces of the electrode material. Such materials are particularly suitable for incorporation in the electric-discharge-machining apparatus described in my Patent No. 3,054,931 and in sparkplugs of the type described in application Ser. No. 281,365.

The ion shield has been found to sharply limit the erosion of the electrode or contact material, this limiting action being apparently a consequence of the elimination of the impact of positive ions which otherwise attack the cathodic electrode and cause pitting of the latter. Best results are obtained in accordance with the principles of the aforementioned earlier application when the electronegative substance was a binary or ternary compound of an electronegative element (e.g. oxygen, carbon, sulfur, fluorine, chlorine and bromine) adapted to release ions of the electronegative element upon development of a discharge in the region of the effective electrode surface. Even if ions of the electronegative element are not physically discharged into the surroundings to form the ion shield, e.g. in the case of contact materials, they nevertheless insure a reduction of the wear, i.e. the electrical erosion, of the negative material.

Generally speaking, optimum results were obtained when the electronegative substance was a metal carbide, oxide, sulfide or halide forming a solid solution with the base metal which advantageously was constituted in major part of the metal forming the electronegative compound. Broadly speaking, the earlier system, set forth in copending application Ser. No. 281,365, made effective use of oxides of copper, tin, manganese, aluminum, chromium and tungsten; the carbides of iron and molybdenum; and sulfides of iron and copper among others.

It is the principal object of the present invention to extend the principles initially set forth in the abovementioned copending application to other electro- and contact-material systems.

A more specific object of the present invention is to provide an improved electrode material having a high resistance to electrical erosion, a high resistance to heat and little tendency to permit diffusion of contaminants such as carbon into the lattice of the electrode material.

Still another object of this invention is to provide improved contact materials for switching and contact-welding devices (e.g. spot-welding electrodes) having exceptionally long life and low contact resistance.

Yet another object of this invention is to provide an improved sparkplug for internal-combustion engines.

A further object is to provide improved heat-resistant materials for use in electrode systems, contact devices, cutting tools and bearings.

The foregoing objects are attained, in accordance with the present invention, through the provision of a heat-resistant, low-wearing material consisting in major part of a base metal with between 0.2 and 10% by weight of an oxide selected from the group which consists of copper oxide (CuO and Cu_2O), iron oxide (FeO, Fe_2O_3 and Fe_3O_4), nickel oxide, sodium oxide (Na_2O), cesium oxide (Cs_2O_3), calcium oxide (CaO), tin oxide (SnO), lead oxide (PbO), zinc oxide (ZnO), beryllium oxide (BeO), silver oxide (Ag_2O), aluminum oxide, and chromium oxide (Cr_2O); the base metal is one selected from the group which consists of copper, iron, nickel, silver, titanium, tin, zinc, cadmium, and lead and may be alloyed with a hardening agent (e.g. chromium or tungsten or a hard base metal from the group given above when a relatively soft base metal is present in major proportions). Thus it is an important principle of the present invention when dealing with contact and electrode materials as well as with materials adapted to constitute low-resistance electrical conductors and heat-resistant tool and bearing materials, to provide a 3-component system wherein the base metal such as silver or copper and the electronegative substance is an oxide of one of these metals or of iron, beryllium, chromium, aluminum, the latter three oxides constituting hardening agents along with the relatively hard metals mentioned above and forming the third component when, for example, copper oxide constitutes the electronegative compound. Surprisingly, it has been found that materials constituted in this manner form excellent conductors and contact materials having relatively low wear and high heat-resistant, presumably as a consequence of the incorporation of relatively refractory compounds such as the chromium, beryllium and aluminum oxides referred to above, these oxides moreover, contributing to the ion shield and augmenting the erosion-reducing character of the contact material.

More particularly, it has been found that the refractory and electronegative substances should be present in an amount ranging from 0.5% up to about 10% by weight of the material with at least the electronegative substances in solid solution within the electrode mass. Especially suitable electrode and contact systems include cuprous oxide (CU_2O) and chromium oxide (Cr_2O) in copper; cuprous oxide and aluminum oxide in copper; chromium oxide and chromium in copper; cuprous oxide and beryllium oxide (BeO) in copper; chromium oxide, beryllium oxide and cuprous oxide in copper; tungsten and silver oxide in silver; and iron and iron oxide in copper. In general, the relatively refractory material should be present in an amount between 0.1% by weight and about 7% by weight with a similar range of proportions for the electronegative substances exclusive of the refractory compound; the sum total of all the oxides in the base metal should, however, be constituted between 1–10% by weight as indicated above. Optimum results are obtained when the Cu_2O quantity is maintained strictly between substantially 3 and 4 % by weight as pointed out in my copending application Ser. No. 281,365.

I have also found that, when between 0.05 and 0.1 gram of certain metal oxides are added in high pervulent form (particle size on the order of 1 micron or a fraction thereof) to the fuel (e.g. gasoline) of an internal-combustion engine per liter thereof, a noticeable decrease in fuel consumption per unit work output results. In general, best results are obtained with oxides decomposing at temperatures between, say, 800° C. and

1000° C., and especially with CuO, Fe_2O_3, Fe_3O_4, PbO, FeO, Na_2O, Cs_2O_3, SnO, CaO and ZnO, FeS being also operative. Fe_2O_3 gives especially good results.

The above and other objects, features and advantages of the present invention will become more readily apparent from the following description, reference being made to the accompanying drawing in which:

FIG. 1 is a diagrammatic view, partially broken away, of a lever-operated switch employing the contact material of the present invention; and

FIG. 2 is an elevational view of a sparkplug incorporating the electrode material of the present invention.

In FIG. 1, I show a simplified electrical switch **10**, whose operating lever **11** is adapted to swing a contact arm **12** into and out of abutting relationship with the stationary contact arm **13**. Both contact arms are provided with wear-resistant contact layers **14** and **15** as described below.

FIG. 2 shows a sparkplug **20** whose central terminal **21** passes axially through the insulating body **22** affixed to the nut **23** carrying an electrode arm **24**. The confronting faces **25** and **26** of terminal **21** and arm **24** are formed with layers of my improved contact material as will be apparent hereinafter.

Example I

A contact material was produced by dissolving 3.4% by weight Cu_2O and 0.5% by weight Cr_2O in a copper-base metal and forming the mass into a switch contact (FIG. 1) having a diameter of 10 mm. and a thickness of 3 mm. The switch was connected in circuit with a 50-cycle/sec. source at 100 volts and a load drawing 20 amperes and was maintained at a temperature of 25° C. Upon opening and closing of the switch 10,000 times, an erosion of 0.014 gram was observed in the presence of ambient air and 0.006 gram when the contacts were immersed in transformer oil. In both cases, the wear of a correspondingly dimensioned copper contact was found to be almost twice as great under similar switching conditions. When the material was constituted as a spot-welding electrode for the joining of aluminum sheets having a thickness of 2 mm., a contact resistance of 8 micro-ohms was obtained at an applied force of 50 kg., 7 micro-ohms at a force of 100 kg., 6 micro-ohms at a force of 200 kg., 5.5 micro-ohms at 300 kg. and 5 micro-ohms at 400 kg. In all cases, the contact potential was found to be slightly below that of the pure copper while the wear of the welding electrode was halved.

Example II

A contact material having the dimensions given in Example I was formed by dissolving 3.4% by weight copper oxide (Cu_2O) and 3% by weight aluminum oxide in copper and the contacts formed from this material were tested for wear resistance and effectiveness as spot-welding electrode as described in Example I. The contact wear in air was 0.02 gram and in oil 0.009 gram whereas increasing spot-welding pressures in the steps given above resulted in contact resistance of 58, 50, 41, 32 and 25 micro-ohms, respectively. In general, the contact material containing the oxides had 40% less wear than copper contacts and were found to be effective spot-welding electrodes with maximum deformability and deterioration of the welding tip due to thermal effects.

Example III

A solid solution was formed by dissolving 0.6% by weight chromium oxide (Cr_2O), 0.3% by weight chromium and 0.2% by weight silver oxide (Ag_2O) in copper. When this material, in the dimensions given above, was subjected to the indicated tests for contact material and welding electrodes, an erosion wear in air of 0.03 gram and in oil of 0.007 gram was observed. In the welding pressure stages described in Example I, the respective contact resistances of 88, 70, 42, 42 and 50 micro-ohms were obtained. The electrode material had 30% greater wear resistance than a copper electrode of corresponding dimensions and was similar thereto in spot-welding characteristics.

Example IV

A solid solution of copper oxide and beryllium oxide is prepared by dissolving 3% by weight of cuprous oxide and 0.5% by weight of beryllium oxide in copper. The resulting material is shaped to the dimensions given in Example I and constituted as the contact material of the switch of FIG. 1. Again a voltage of 100 volts at 50 cycles per second is applied across the switch contacts with a current of 20 amps. Upon opening and closing of the switch 10,000 times, the contact regions show a loss of weight of 0.0088 gram when immersed in oil and 0.019 gram when surrounded by air. When constituted as spot-welding electrodes as described in Example I, contact resistances of 50, 64, 32, 28 and 20 micro-ohms are obtained with welding forces of 50, 100, 200, 300 and 400 kg., respectively. In this case, the contact material is found to have 50% less wear than a conventional copper contact and to have somewhat lower contact resistances when used in spot welding. Deformation of the spot-welding electrode is noticeably less than that of a copper electrode of corresponding configuration.

Example V

A solid solution is prepared by dissolving 2% iron oxide (Fe_2O_3) in copper and testing the resulting material as described in Example I. When constituted as the contact layer of a switch, the contacts show a loss of weight due to erosion of 0.010 gram in oil and 0.014 gram in air. The contact resistances of the electrode when utilized for spot welding was 84, 67, 54, 40 and 30 micro-ohms for the successively increased welding forces of Example IV, respectively. The contact material evidenced 20% less wear than a contact material constituted from pure copper and showed little deformation in the course of spot welding.

Example VI

A contact material and spot-welding electrode was prepared with substantially the same characteristics as those of the material of Example V, except that the erosion in oil was 0.04 gram and the erosion in air was 0.021 gram with successive contact resistances of 110, 80, 65, 55 and 50 micro-ohms, by dissolving 2% by weight beryllium oxide in a copper melt and cooling the product.

Example VII

A highly effective contact material was produced by dissolving 4% by weight cuprous oxide, 2% by weight beryllium oxide and 0.3% by weight chromium oxide in a copper melt and cooling the mass. When tested as described in Example I, the contacts produced from this material had a loss in weight in air of 0.008 gram and a loss of weight in transformer oil of 0.007 gram. Successive contact forces of 50, 100, 200, 300 and 400 kilograms gave contact resistances of 100, 80, 60, 54 and 52 micro-ohms, respectively, for a spot-welding electrode of this material against aluminum. From this sequence of examples, it has been seen that the best contact materials are those which contain cuprous oxide in an amount between 3 and 4% by weight (i.e. the materials produced in accordance with Examples VII, I, IV and II, in the order of efficiency) and that the presence of at least one additional refractory oxide compound (as in each of these examples) further improves the contact weight resistances.

Example VIII

A cutting tool for the high-speed turning of metals on lathes or the like is composed of a solid solution of iron oxide (Fe_2O_3) in high-speed steel (0.26% carbon, 0.92% chromium, 0.20% vanadium, 4% molybdenum and 10% tungsten, balance iron). The amount of the iron oxide in

the steel is about 10%. In the absence of the iron oxide, the high-speed steel cutting tool generates approximately one third more heat than that produced by the composition of the present invention which maintains its edge for a period of two to three times longer than is possible with the ordinary steel cutting tool omitting iron oxide.

Example IX

A highly effective discharge material for the sparkplug of FIG. 2 is produced by dissolving 10% Fe_2O_3 in 18–8 stainless steel (0.13% carbon, 8% nickel, 18% chromium, balance iron). The sparkplug material resists diffusion of carbon into the steel lattice and lasts 2 to 3 times longer than a sparkplug having tungsten-steel electrodes. There is no corrosion evident when the sparkplug containing the improved material is subjected to 10,000 km. of driving time in a six-cylinder automotive-vehicle engine.

Example X

A bearing material having a high degree of heat resistance but a low coefficient of friction was prepared by dissolving 8% cuprous oxide and 12% tin (all percents by weight) in copper. This material was found to have the bearing efficiency of a bronze bearing containing 84% copper and 16% tin but with a substantially higher ultimate strength, yielding point and elastic limit. An impact test gave an Izod rating of about seven.

Example XI

A product having the low coefficient of friction of the product of Example X as well as high impact strength and heat resistance was produced by dissolving 10% by weight tin oxide (SnO) in a bronze bearing alloy consisting of 20% tin and 70% copper when the oxide is added.

Example XII

A series of sparkplug electrode materials was produced by forming a solid solution of 3.4% by weight cuprous oxide in copper; 3% by weight silver oxide in copper; 5% by weight Fe_2O_3 and 5% iron in copper; and 4% nickel oxide in copper. Similar sparkplugs composed of each of these spark materials and a control electrode using nickel sparking material were installed in an internal-combustion engine. The nickel sparkplug gave an engine speed of 1500 r.p.m. in a loaded condition and 2590 r.p.m. in an unloaded condition with a fuel consumption unloaded of 2.6 cc. per minute. The sparkplugs containing copper oxide, silver oxide, iron oxide and nickel oxide had loaded speeds of 1620, 1740, 1600 and 1580 r.p.m., and unloaded speeds of 2580, 2590, 2570 and 2560 r.pm., respectively, with fuel consumptions of 2.1, 2.2, 2.4 and 2.5 cc. per minute.

Example XIII

Sparkplugs were produced by dissolving 3% by weight of each of the following electrode negative compounds in copper: CuO, Fe_2O_3, Fe_3O_4, PbO, FeO, Na_2O, Cs_2O_3, CaO, FeS, SnO and ZnO. Each of these sparkplugs was tested in a sixty horsepower internal-combustion engine at

a speed corresponding to a vehicle speed of 25 km. per hour accelerated to 50 km. per hour. The test showed that each of the electrodes was capable of withstanding temperatures of 800° C. to 1000° C. and produced ion shields as previously described. A 15% gain in mileage per liter of fuel consumed over conventional sparkplugs with nickel electrodes was common.

Example XIV

A sparkplug whose electrode material consists of 5% Fe_2O_3 and 5% Fe in copper was tested in an internal-combustion engine connected to an electric generator against a conventional electrode of the type described above. When the generator produced 55 volts at 142 amps., the speed of the engine was 1990 r.p.m. with a fuel consumption of 18.7 cc. per minute with the conventional sparkplug and 1990 r.p.m. at 14.2 cc. per minute with the plug using the iron oxide composition indicated. When the generator produced 82.5 volts at 30 amp., the conventional sparkplug resulted in an engine speed of 3000 r.p.m. with a fuel consumption of 23.3 cc. per hour, whereas the material of the present invention required only 28.5 cc. per hour of fuel at 2980 r.p.m. The sparkplug was tested 30,000 to 80,000 times without failure and had an operating life 1.5 times greater than the conventional electrode. It was found that between 1 and 10% by weight of iron oxide and iron was effective.

The invention described and illustrated is believed to admit of many modifications within the ability of persons skilled in the art, all such modifications being considered within the spirit and scope of the appended claims.

I claim:

1. As a new composition of matter, a nickel-chromium stainless steel containing between substantially 1 and 10% by weight Fe_2O_3.

2. A machining tool consisting of high-carbon steel containing between substantially 1 and 10% by weight Fe_2O_3.

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