METHOD FOR PRODUCING A CONTACT REED

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ABSTRACT
A method for producing a contact reed especially suitable for use in a reed switch to ensure a long life and low electric contact resistance of the switch, comprising electrolytically polishing the reed which is conducted in an electrolyte of H₃PO₄ being kept at a temperature range of from about 50°C to 60°C under the application of an electric current of from about 2 to 5 A/dm² for from about 40 to 50 minutes to obtain a reed which will have a slightly rounded and smooth surface after being plated and then plating the electrolytically polished reed. The contact reed made thereby has a flat surface which is free from partial contact and undesirable pits.

25 Claims, 15 Drawing Figures
FIG. 1

FIG. 2A

FIG. 2B

FIG. 3A
PRIOR ART

FIG. 3B

FIG. 12

FIG. 13

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1. FIELD OF THE INVENTION

This invention relates to methods for producing contact reeds. The term "contact reed" used in this invention is intended to denote those contact elements employed in, for example, a switch which permits the transfer of current when these contact elements are brought into contact with each other. Thus, this invention relates to an improved method for producing a contact reed for use in a switch, and more particularly to a novel and improved method for producing a contact reed for use in a reed switch in which the contact pressure between the contact reeds is very small. In the following description, the present invention will be described with specific reference to contact reeds for use in such a reed switch rather than reference to commoner contact reeds used in conventional switches. However, it will be understood that the present invention includes the manufacture of common contact reeds used in conventional switches.

2. DESCRIPTION OF THE PRIOR ART

A reed switch is a sort of electrical switch means which comprises a pair of contact reeds of metal material disposed opposite to each other in an evacuated glass tube or in a glass tube filled with an inert gas such as argon and is adapted to operate in such a manner that the pair of metal contact reeds are urged into contact or released from the contacting state in response to the on-off application of an external magnetic field thereby to make or break a circuit. The matter to which the greatest consideration should be given in connection with the manufacture of a reed switch of the structure described above is how to minimize the electrical contact resistance appearing in the contact area when the two contact reeds are brought into contact with each other, for if a high electrical contact resistance should exist in the contact area, a large voltage drop would take place across the contact reeds to give rise to electric discharge or the generation of heat in the contact area due to the high resistance. These phenomena would give rise to trouble including excessive consumption of the contact reeds, deterioration of the material of the reeds, and an unsatisfactory state of contact.

The desired minimization of the contact resistance between the contact reeds of the reed switch has a concern with the material of the contact reeds as well as the contact pressure between the contact reeds, but a more important and decisive factor is the state of surface finish of the contact reeds. This is because the contact area between the contact reeds will vary greatly depending on the state of surface finish thereof and hence the electrical resistance will correspondingly greatly vary in view of the fact that the state of contact between the contact reeds is a fact-to-face contact.

Therefore, a considerable effort has hitherto been made for the successful manufacture of the contact reeds of the kind described above. One of the conventional manufacturing methods which is likely to be the best of them comprises the basic steps of pressing to flatten a raw material, cutting a workpiece of suitable length from the flattened raw material, abrading the workpiece by the barrel method, annealing the workpiece, subjecting the workpiece to a pretreatment including electrolytic cleaning in a solution such as a sodium cyanide solution, supersonic cleaning and chemical cleaning in an aqueous solution of an acid of alkali, and plating the workpiece for the surface finish thereof. In the Privat Patent, U.S. Pat. No. 3,251,121, which is one of the conventional methods, the surface of the workpiece is subjected to a pretreatment including a hot acid dip and a vapor phase degreasing for making a plating of coating materials onto the surface of the workpiece easy by activating the surface of the workpiece. And also, in the Fletcher Patent (U.S. Pat. No. 1,417,896), Kushner Patent (U.S. Pat. No. 2,227,454), and Bennert Patent (U.S. Pat. No. 2,730,494), the metal surface is subjected, for example, to an electrolytic cleaning treatment by immersing the metal in an acid bath containing a salt of copper, to a solution of hydrofluorosilicic acid, or to an anodic treatment in a solution of hydrochloric acid and water for cleaning the metal surface so that a firm and coherent coating of the deposited metal can be directly obtained on the metal surface, for cleaning all of the oxide on the metal surface so that the coating material may cling, for removing a burr from the metal, or for forming a clean, bright surface of the metal.

However, the greatest defect of the contact reed manufactured in accordance with such methods resides in the fact that the longitudinal and edges of the contact reed are thickly plated to have a larger thickness than the remaining portions and thus the contact reed has a surface contour which is concaved at the central portion thereof. Such a surface contour is undesirable for the contact reeds when they are used in a switch because non-uniformity or partial contact is produced in the contact area resulting in an incomplete contact between the contact reeds which are brought into contact with each other in the switching operation. Furthermore, very fine impurity particles of an abrasive such as Al₂O₃, Cr₂O₃ or SiO₂ employed in the abrading step are forced into the contact reed and these impurity particles cannot be removed even with the cleaning step following the abrading step. Such an impurity prevents the otherwise satisfactory deposition of the plating layer and would produce undesirable pits in the contact surface and cause a resultant increase in the electrical contact resistance. Moreover, the partial contact between the contact reeds would give rise to a larger degree of wear at that portion of the contact reeds and reduce the service life of the contact reeds. Further, in the conventional methods, the metal surface was only cleaned or strongly etched since the electric current in the pretreatment was too small or too large to etch the surface of the metal. As the result of the strong etching, the metal surface became rough.

SUMMARY OF THE INVENTION

It is therefore a primary object of the present invention to provide a method for producing a contact reed which has a surface contour giving a small contact re-
istance and is substantially free from wear thus having a long service life.

A further object of the present invention is to provide a method for manufacturing a contact reed which is free from the undesirable partial contact at the longitudinal end edges thereof and has a uniformly plated finished surface free from the presence of objectionable pits therein.

These and other objects, advantages and features of the present invention will be more apparent from the following detailed description with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a schematic perspective view showing the shape of a contact reed blank which is obtained by pressing to flatten the raw material in the form of a wire and then cutting a piece of suitable length from the flattened wire.

FIG. 2A is a schematic perspective view of a contact reed produced by the method embodying the present invention.

FIG. 2B is a sectional view taken on the line X—X in FIG. 2A.

FIG. 3A is a schematic perspective view showing the external shape of a conventional contact reed produced by the prior method including the step of abrading by the barrel method.

FIG. 3B is a sectional view taken on the line Y—Y in FIG. 3A.

FIG. 4 is a microphotograph enlarged at a magnification of 1000 times showing the surface state of a contact reed after it has been subjected to electrolytic polishing according to the method of the present invention.

FIG. 5 is a microphotograph enlarged at a magnification of 1000 times showing the surface state of a conventional contact reed after it has been subjected to barrel abrading according to the prior method.

FIG. 6 is a microphotograph enlarged at a magnification of 1000 times showing the surface state of the conventional contact reed after it has been subjected to barrel abrading and then to annealing.

FIGS. 7 to 9 are microphotographs showing the surface state of the conventional contact reed after it has been subjected to barrel abrading according to the prior method, the microphotographs being taken by an X-ray microanalyzer at a magnification of 1000 times, wherein FIG. 7 represents a microphotograph taken with Al-characteristics rays, FIG. 8 represents a microphotograph taken with O₂-characteristics rays and FIG. 9 represents a microphotograph taken with Fe-characteristics rays.

FIGS. 10 and 11 are microphotographs showing the surface state of the contact reed produced by the method of the present invention and the conventional one produced by the prior method, respectively, the microphotographs being taken at a magnification of 60 times.

FIG. 12 is a graphic illustration of the number of integrated failure counts relative to the number of switching times in the conventional contact reed obtained by the prior method.

FIG. 13 is a graphic illustration of the survive ratio of stick failure relative to the number of switching times in the conventional contact reed obtained by the prior method.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The method according to the present invention is entirely the same as the prior method described previously in that it also comprises the initial steps of pressing to flatten a raw material in the form of a wire and cutting a piece of suitable length from the flattened wire to obtain a blank or workpiece of a shape as seen in FIG. 1. However, the present invention differs in the subsequent steps from the prior method which includes abrading the workpiece by the barrel method and then plating the workpiece to cover it with a metal layer. More precisely, the present invention is characterized by the steps of rough polishing the workpiece by the barrel method, annealing the workpiece, electrolytically polishing at least the contact portion of the annealed workpiece to such an extent that the workpiece after being plated will have a slightly rounded and smoothed surface, and finally plating the workpiece to obtain a contact reed.

In case of necessity, before plating the workpiece is subjected to a pretreatment including electrolytic cleaning in a solution such as a sodium cyanide solution, supersonic cleaning and chemical cleaning in an aqueous solution of an acid or alkali for activating the surface of the workpiece.

The contact reed produced in accordance with the method of the present invention described above has its longitudinal end edges rounded off and has its contact surface 1 shaped to a planar form having very gentle convex roundness all over as seen in FIGS. 2A and 2B. Thus, the contact reed obtained in accordance with the present invention differs distinctly from the prior contact reed structure which is thickened at longitudinal end edges 2 and has its contact surface 3 formed as a concave plane as seen in FIGS. 3A and 3B.

The concave contact surface and the thickened longitudinal end edges in the prior contact reed structure are considered to result from the fact that the end edge portions are more thickly plated than the remaining flat portions in the plating step due to an extremely higher current density at the end edge portions than at the remaining flat portions and the end edge portions are electrolytically removed more than the remaining flat portions in the subsequent electrolytic polishing step. In contrast, the electrolytic polishing step is followed by the finish plating step according to the method of the present invention. Accordingly, the metal portion removed from the end edges of the workpiece is substantially offset by the coating portion subsequently added to the end edges of the workpiece, and the contact reed finally obtained can be shaped to have a surface contour of very gentle convex roundness all over.

The gently convexly rounded shape ensures a sufficient contact area desired for the contact reed even if the contact reed may be somewhat incorrectly mounted and thus reduces the possibility of the contact resistance becoming excessively high. Furthermore, the gently convexly rounded shape eliminates unusual wear which may take place due to non-uniform or partial contact between a pair of contact reeds, thereby correspondingly extending the service life of the contact reeds.
The present invention will now be described in more detail by reference to a practical example.

A wire which is a raw material of the contact reed is pressed to flatten to a thickness in the order of 0.2 mm by a conventional press machine such as a hydraulic press. A workpiece of suitable length, for example, 1 to 3 cm long is cut from the flattened wire and is then shaped to approximate dimensions by rough polishing by the barrel method. The approximately shaped workpiece is then annealed to remove the stress produced during the pressing, and is subsequently subjected to electrolytic polishing. The electrolyte suitable for this purpose may be H₃PO₄, H₂SO₄, HCl or any other electrolyte conventionally employed in electrolytic polishing. After the electrolytic polishing, water remaining on the workpiece must be removed. Removal of water can substantially be attained by heating the workpiece for about 3 minutes at about 200°C. The temperature of the electrolyte in the electrolytic polishing should desirably be of the order of 40⁰C to 90⁰C., and the current density should desirably be of the order of 1 to 10 amperes per square decimeter, and the duration of current supply is desirably of the order of 30 to 60 minutes. The electrolysis will proceed extremely slowly and an undesirable reduction in the industrial productivity would result in case the temperature and the current supply are less than the above-specified values. Moreover, in case the temperature and the current supply exceed the above-specified values, the electrolysis will proceed very quickly and the contact reed to be worked will have a rough surface, which gives rise to the defect of an unsatisfactory state of contact and an increase in the contact resistance. Contact reeds having remarkably excellent operating characteristics could be obtained when the temperature of the electrolyte, and the current density and the duration of current supply were set at 50⁰C to 60⁰C and 2 to 5 amperes per square decimeter and 40 to 50 minutes, respectively. The workpiece subjected to electrolytic polishing in the above manner is then plated with gold or silver to obtain a contact reed which is free from pits of like objectionable spots and has a very smooth surface.

In the photographic representations of the microstructure of the contact reed given in FIGS. 4 to 11, the contact reed is made from a 52% Ni - 48% Fe alloy.

FIG. 4 represents a microphotograph enlarged at a magnification of 1,000 times showing the surface state of the contact reed after it has been subjected to electrolytic polishing in accordance with the method of the present invention. It will be seen from FIG. 4 that the contact reed has a very smooth surface.

FIGS. 5 and 6 represent microphotographs enlarged at a magnification of 1,000 times showing the surface state of a conventional contact reed after it has been subjected to abrading by the barrel method and then to annealing treatment in accordance with the prior method, respectively. Black spots seen in FIGS. 5 and 6 are particles of alumina (Al₂O₃) used as an abrasive, and thus it will be seen that the conventional contact reed has a very rough surface state compared with the surface state of the contact reed according to the present invention shown in FIG. 4.

FIGS. 7 to 9 represent microphotographs taken by an X-ray microanalyzer to investigate the surface state of the conventional contact reed after it has been subjected to abrading by the barrel method in accordance with the prior method. Spots seen in FIGS. 7 to 9 apparently indicate the fact that impurity particles of the abrasive become attached to the surface of the contact reed. The microphotographs shown in FIGS. 7 to 9 are taken with Al-characteristics rays, O₂-characteristics rays and Fe-characteristics rays, respectively. These microphotographs verify the fact that the particles of alumina used as the abrasive attach to the surface of the contact reed and the rough surface state as seen in FIG. 5 or 6 is thereby formed.

FIG. 10 represents a microphotograph enlarged at a magnification of 60 times showing the surface state of the contact reed after it has been subjected to the electrolytic polishing and then to finish plating treatment in accordance with the method of the present invention. The central part designated by the reference character A indicates the portion with which the contact reed contacts an opposite contact reed, and it will thus been seen that the contact reed is provided with such a wide contact area.

In contrast, as seen in FIG. 11 representing a microphotograph enlarged at a magnification of 60 times, the conventional contact reed made according to the prior method contacts with an opposite contact reed by a plurality of partial contact portions B, and thus the conventional contact reed has an extremely undesirable surface state.

From a mere glance at FIGS. 4 to 11, it will be understood that the method according to the present invention is far superior to the prior method. The performance of a reed switch employing the contact reed made according to the present invention will be described hereunder. Typical indices representing the performance of a reed switch include (1) the number of integrated failure counts and (2) the survive ratio of stick failure in percent. In seeking the number of integrated failure counts, five reed switches are connected in series and every occasion on which the total contact resistance of these reed switches exceeds one ohm is counted as a failure. In seeking the survive ratio of stick failure, an operation circuit including a multiplicity of reed switches having a voltage applied across the contact reeds thereof is prepared, and these reed switches are simultaneously energized. Those contact reeds on which stick-like projections are formed due to electric discharge are removed as rejections, and the ratio of the number of the remaining normal contact reeds to the number of all the contact reeds employed is sought to obtain the survive ratio of stick failure in percent.

As will be apparent from the characteristic shown in FIG. 12, the number of integrated failure counts in the case of the conventional contact reed made according to the prior method shows an abrupt increase at the number of switching times of 17 to 19 millions, and as will be also apparent from the characteristic shown in FIG. 13, the survive ratio of stick failure shows an abrupt decrease at the number of switching times of 7 to 8 millions. In the case of the contact reed made according to the method of the present invention, it is to be noted that an experiment is still in progress in which the reed switch has already been turned on-off more than 40 million times without any increase in the number of integrated failure counts and any decrease in the survive ratio of stick failure.
We claim:
1. A method for producing a contact reed usable as a conductor element in a contact device, said reed having a contact portion covered with a contact coating of a conductive material, which comprises the steps of: cutting out a workpiece from an iron-containing conductor metal and shaping it into a flat elongated shape; polishing said shaped workpiece to clean up the surface thereof; annealing said polished workpiece to remove the stress existing therein; electrolytically polishing said annealed workpiece at least on a predetermined portion thereof which is to be provided later with a conductive coating thereon for sufficient time to slightly round off the elongated end edges of said workpiece in an electrolyte conventionally employed in electrolytic polishing; and thereafter electrically metal plating over the polished surface of said workpiece to provide a contact metal coating on said predetermined portion of said workpiece and to obtain a contact reed having a contact portion with a substantially flat surface.

2. A method for producing a contact reed according to claim 1, in which said electrolytic polishing is conducted with a current of about 1 to 10 A/dm² in an electrolyte heated to a temperature of 40° to 90° C.

3. A method for producing a contact reed according to claim 2, wherein said current is from about 2 to 5 A/dm² and said temperature is from about 50° to 60° C.

4. A method for producing a contact reed according to claim 3, wherein said electrolytic polishing is conducted for from about 30 to 60 minutes.

5. A method according to claim 4, wherein said electrolytic polishing is conducted in an electrolyte selected from the group consisting of H₃PO₄, H₂SO₄, and HCr₂O₇.

6. A method for producing a contact reed according to claim 3, wherein said electrolytic polishing is conducted for from about 40 to 50 minutes.

7. A method for producing a contact reed according to claim 6, wherein said electrolytic polishing is conducted in an electrolyte of H₃PO₄.

8. A method according to claim 1, wherein said electrolytic polishing is conducted in an electrolyte selected from the group consisting of H₃PO₄, H₂SO₄, and HCr₂O₇.

9. A method for producing a contact reed according to claim 1, wherein the workpiece is electrolytically polished for a sufficient time to obtain a convex shape.

10. In a method for producing a contact reed having a contact portion covered thereon with a contact coating of conductive metal, the improvement which comprises the steps of: electrolytically polishing a predetermined portion of a flat elongated workpiece made of an iron-containing metal which is to be coated later with a conductive metal layer for a sufficient time to slightly round off the elongated end edges of said predetermined portion of the workpiece in an electrolyte conventionally employed in electrolytic polishing; and thereafter electrically metal plating over the polished surface at least on the predetermined portion of said workpiece so as to coat said portion with a conductive metal layer, and to obtain a substantially flat conductive metal coating on the workpiece.

11. A method for producing a contact reed according to Claim 10, in which said electrolytic polishing is conducted with a current of about 1 to 10 A/dm² in an electrolyte heated to a temperature of 40° to 90° C.

12. A method for producing a contact reed according to claim 11, wherein said current is from about 2 to 5 A/dm² and said temperature is from about 50° to 60° C.

13. A method for producing a contact reed according to claim 12, wherein said electrolytic polishing is conducted for from about 30 to 60 minutes.

14. A method according to claim 13, wherein said electrolytic polishing is conducted in an electrolyte selected from the group consisting of H₃PO₄, H₂SO₄ and HCr₂O₇.

15. A method for producing a contact reed according to claim 12, wherein said electrolytic polishing is conducted for from about 40 to 50 minutes.

16. A method according to claim 10, wherein said electrolytic polishing is conducted in an electrolyte selected from the group consisting of H₃PO₄, H₂SO₄ and HCr₂O₇.

17. A method for producing a contact reed according to claim 10, wherein the workpiece is electrolytically polished for a sufficient time to obtain a convex shape.

18. A method for producing a contact reed usable as a conductor element in a contact device, said reed having a contact portion covered with a contact coating of a conductive material, which comprises the steps of: cutting out a workpiece from an iron-nickel alloy and shaping it into an elongated flat shape; polishing said shaped workpiece to clean up the surface thereof; annealing said polished workpiece to remove the stress existing therein; electrolytically polishing said annealed workpiece at least on a predetermined portion thereof which is to be provided later with a conductive coating thereon in an electrolyte selected from the group consisting of H₃PO₄, H₂SO₄ and HCr₂O₇ heated to a temperature of 40° to 90° C.

19. A method according to claim 18, wherein said electrolytic polishing is conducted in an electrolyte of H₃PO₄.

20. A method for producing a contact reed according to claim 18, wherein said electrolytically polishing is conducted in an electrolyte selected from the group consisting of H₃PO₄, H₂SO₄ and HCr₂O₇ heated to a temperature of 50° to 60° C and having a current of about 2 to 5 A/dm² for from about 40 to 50 minutes.

21. A method according to claim 20, wherein said electrolytically polishing is conducted in an electrolyte of H₃PO₄.

22. In a method for producing a contact reed having a contact portion covered thereon with a contact coating of conductive material, the improvement which comprises the steps of: electrolytically polishing a predetermined portion of workpiece which is to be coated later with a conductive material layer in an electrolyte selected from the group consisting of H₃PO₄, H₂SO₄ and HCr₂O₇ heated to a temperature of 40° to 90° C with a current of about 1 to 10 A/dm² for from about 30 to 60 minutes; and thereafter electrically plating a contact coating of a conductive material selected from the group consisting of gold and silver over the polished surface at least on the predetermined portion of said reed.
23. A method according to claim 22, wherein said electrolytic polishing is conducted in an electrolyte of H₃PO₄.

24. A method for producing a contact reed according to claim 22, wherein said electrolytically polishing is conducted in an electrolyte selected from the group consisting of H₃PO₄, H₂SO₄ and HCr₂O₇ heated to a temperature of 50° to 60° C with a current of about 2 to 5 A/dm² for from about 40 to 50 minutes.

25. A method according to claim 24, wherein said electrolytically polishing is conducted in an electrolyte of H₃PO₄.

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