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CONTACT BANK FOR A SWITCHING DEVICE

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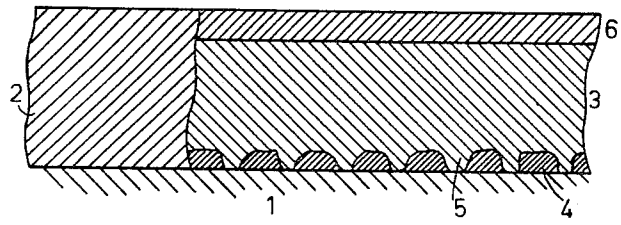



Fig. 1

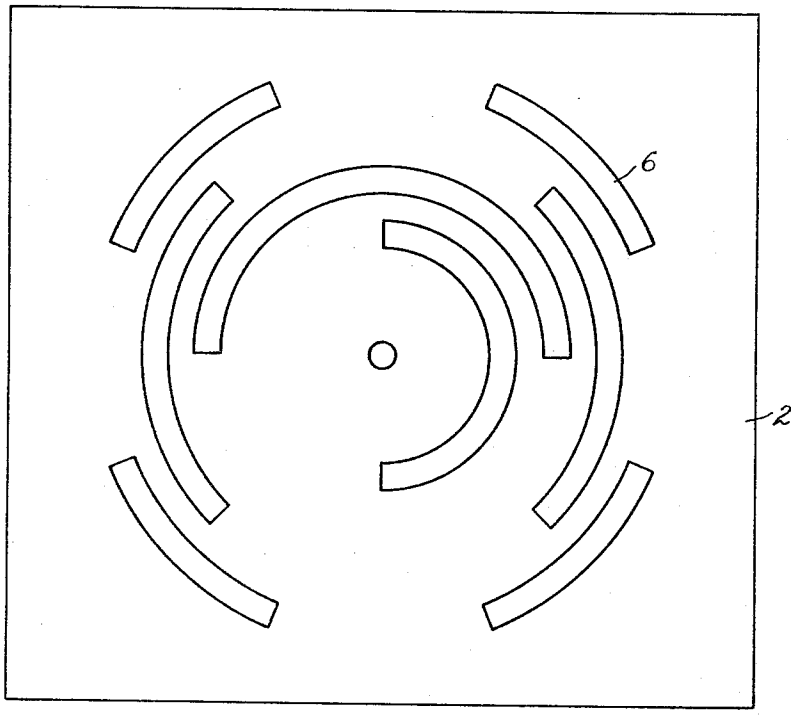



Fig. 2

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# CONTACT BANK FOR A SWITCHING DEVICE

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5 Claims. (Cl. 200—166)

The invention relates to a contact bank for a switching device and to a method for making the same.

Generally a contact bank for a switching device is built by mounting each of the contact elements separately onto the switching device. If these contact elements are not adjacent, as will generally be the case in digitalising switches, the contact elements are either countersunk into a layer of isolating material, or parts of isolating material are mounted between non-adjacent contact elements, care being taken that the surfaces of the contact elements and that of the isolating material are in the same plane. Contact banks of this type have various disadvantages. Their construction requires much work and is, therefore, relatively expensive. It is very difficult to build small switches in this way, and yet in many cases, for instance in building digitalising switches, small dimensions are highly desirable. Moreover, the isolating material wears more rapidly than the material of the contact elements, which causes the switching devices to become obsolete very soon. Especially in contact devices in which rapidly moving contact arrangements cooperate with the contact banks the unevenness of the contact banks caused by wear will make the contact devices vibrate, so that no reliable contact can be established. Moreover the pulverised material which is produced by the wear of the isolating parts of the contact bank will smudge the contact elements and this is prejudicial to the reliability of the contact between the contact arrangements and the contact bank. Moreover it is very difficult to arrange the contact elements in small switching devices with sufficient accuracy such that the switching manipulations will take place in well-defined positions of the contact arrangements.

The invention substantially obviates the above drawbacks. According to the invention the contact bank comprises a number of metal contact elements which, in the form of a precipitation of metal, are fixedly connected to an aluminium surface carrying these contact elements, the part of the aluminium surface situated beyond the contact elements being covered by an anodised layer, at any rate in so far as the area over which any contact arrangement cooperating with the contact bank moves during the relative motion of contact arrangement and contact bank is concerned.

The anodised layer is not only an excellent isolator but is, moreover, very resistant to wear. Consequently it is possible for the surface of the anodised layer and the surface of the contact elements to remain in the same plane without any unevenness after these surfaces have been made even and smooth by grinding, polishing or lapping, so that during a relatively long life of the switching device all unevenness in the region of the separations between the anodised surface and the contact surface will be avoided. For this reason the contact bank according to the invention constitutes an important improvement in rapidly moving switching devices.

According to the invention the contact bank described above can be produced by the following method. Firstly the aluminium surface which is to carry the contact bank is made even and anodised. Then the anodised surface is covered by a photosensitive layer of a type that can be used in making printing plates, and this photosensitive



layer is exposed under a negative which is a representation of the contact elements that are to be made in the bank. Then the exposed surface is developed in a developer suitable for the layer used, as a result of which the photosensitive layer is removed from the anodised layer on the places where the contact elements are to come. Then the surface is immersed in a fluid that dissolves the anodised layer but does not affect aluminium, and finally the parts of the surface where the original anodised layer is removed are covered by a metal precipitation in a chemical bath suitable for this purpose, for instance an electroplating bath. In applying this method both a photosensitive material which can only be dissolved by the developer after it has been exposed to light as well as a photosensitive material which can be dissolved by the developer but hardens under the influence of light can be used. In the second case the negative must show the contact elements as dark patches on a diaphanous background, whilst in the first case these contact elements must be represented as diaphanous patches on a dark background. The precipitation of the contact metal can be effected by electrolysis as well as by reduction.

Experience has shown that in certain circumstances the method described above may lead to imperfections. Nickel, for instance, because of its excellent resistance to wear, is a very good material for carrying a contact surface. It is, however, not a simple problem to produce a nickel layer which effectively adheres to an aluminium surface. For this purpose the aluminium surface is generally first covered with zinc, but the zinc baths used for this purpose are basic and consequently affect the anodised layer. In connection therewith a further development of the invention has been undertaken and this has led to an excellent embodiment of a contact bank according to the invention and a special method for making this bank. In this new embodiment the metal contact elements are connected to the aluminium supporting surface by means of an anodised layer with increased porosity, which covers said surface at those places where the contact elements are present, the contact elements being connected to the aluminium surface through the pores in the layer with increased porosity. In a method for making said embodiment, between the removal of the anodised layer and the precipitation of the metal contacts, the parts of the aluminium surface which will have to be covered by the contacts are first covered by an anodised layer with increased porosity in a bath which promotes the porosity of this layer, this layer being made less thick than the anodised layer present beyond the parts where the contacts are to come.

Experience has shown that without any difficulty an excellently adhering metal precipitation, such as a nickel precipitation, can be made on this layer with increased porosity. This precipitation can be effected electrolytically as well as by reduction.

The invention will now be described by referring to the particular embodiments shown in the drawing in which:

FIG. 1 shows a partial section of a contact element in a contact bank according to the invention.

FIG. 2 shows a top view of a number of concentric contact banks for a digitalising switch which can be made according to the invention.

FIG. 1 shows a partial section of a small part of a contact bank according to the invention. The part is situated at either side of the separation between an isolated part and a contact element, and is greatly enlarged. The actual thickness of the part shown is not more than 25$\mu$. The contact bank is carried by an aluminium plate, the upper surface of which carries the reference 1. Beyond the contact elements this plate is covered by an anodised

layer carrying the reference 2 and consisting of aluminium-oxide. The thickness of this layer is about 20μ. The contact element, only a small part of which is shown, consists of two layers, the layer 6 and the layer 3. The layer 3 consists of an electrolytical precipitation of semi-bright nickel. This material is very strong and tough and constitutes an excellent supporting surface for a contact surface. It is more suitable for this purpose than electrolytical bright nickel, which is so brittle that a contact element consisting of this material will easily come away from its supporting layer as a result of temperature variations and the differences in expansion resulting therefrom. The nickel layer does not rest directly on the aluminium surface 1. Between this nickel layer and the aluminium surface there is a porous anodised layer 4, which also consists of aluminium oxide but has a large number of pores such as 5 and has a thickness of 3 to 5μ. This layer causes the nickel layer to adhere better to the aluminium surface. The nickel layer is electrically connected to the aluminium layer 1 through the pores 5. The surface of the contact element does not consist of nickel. The passage of current through a contact with a nickel surface is not very reliable. The contact resistance of a contact point with a nickel surface can sometimes, for no identifiable reason, suddenly increase considerably. In connection therewith the nickel layer 3 is made so that its upper surface is slightly lower than that of the anodised layer 2. In a practical embodiment the thickness of the nickel layer is about 12μ while the total thickness of the porous anodised layer and the nickel layer together is 15μ. This nickel layer is covered by a thin layer 6 consisting of an electrolytical plating of hard gold with a thickness of about 5μ. Hard gold is an excellent contact material. Owing to its hardness it wears only very slightly. Because of the fact that it is carried by a nickel supporting layer no deformations will occur. In making the contact bank the gold layer is made slightly too thick. Afterwards the contact bank is polished or lapped, causing the anodised layer and the gold layer to be given a common plane surface, so that no unevenness will occur at the boundary between a contact element and the anodised layer.

In making the contact bank according to the invention the correct dimensions can be maintained within very small limits. The accuracy of the dimensions and the situations of the boundaries between contacts and isolating surface are mainly determined by the negative under which the photosensitive layer is exposed when making the contact bank. This negative can be made in the form of a reproduction in reduced dimensions of a drawing on a considerably larger scale which may have a high relative accuracy. This method permits the manufacture of contact banks of very small dimensions and of very great accuracy. This is especially important in digitalising switches which are to digitalise the position of a shaft or of an object which can be moved along a straight or an otherwise shaped trajectory.

A reasonably accurate digitalising of such a position will require eight to ten adjacent or concentric contact banks. If these contact banks are made according to classic methods they become very cumbersome. Digitalising switches with concentric contact banks according to the invention have, however, been made in which the difference between the radii of two adjacent concentric contact banks is not more than 2 to 2.5 millimeters. A combination of ten such concentric contact banks for a digitalising switch that permits an angular position to be digitalised with an accuracy which is better than 0.5 degrees, can be built in an embodiment according to the invention on a plate with a diameter with is not much larger than five to six centimeters. This clearly shows the advantages of the method according to the invention.

FIG. 2 shows representations of the contact elements of four concentrical contact banks of a digitalising switch according to the invention that can be arranged on one single plate. In manufacturing a contact bank according to the invention one begins with an aluminium surface, for instance the surface of an aluminium plate. This surface is ground and/or polished or lapped in order to make it flat and very smooth. Then this surface is anodised. The anodised layer thus obtained should be fairly compact in order that it may constitute an excellent isolator in the switch and will not be covered by a metal layer when the contact elements are manufactured by plating. Moreover, this anodised layer should be fairly thick; its thickness should be equal to the total thickness of all the layers which will be incorporated in each space reserved for a contact element. In a practical embodiment it appears to be desirable to apply an anodised layer of at least 20μ thickness. Such a layer can only be manufactured if it has a small amount of porosity. It can be made in a bath containing a few percentages of oxalic acid to which a voltage of about 70 v. is applied. After this layer has been manufactured it is cleaned and then covered with a photosensitive layer of a type which are used in making printing plates. After this photosensitive layer has been applied to the anodised layer it is exposed under a negative that is a representation of the contact elements to be made, after which it is developed, so that on the places where the contact elements will be located the photosensitive layer is removed. Two types of material are available for such photosensitive layers. One type is naturally soluble in the developer but becomes insoluble under the influence of light. If such a photosensitive layer is used the negative must show the contacts as dark patches on a diaphanous background. The other type of photosensitive layer is naturally insoluble and becomes soluble under the influence of light. If this type of layer is used the contacts must be shown on the negative as diaphanous patches on a dark background. The advantage of this material for the photosensitive layer is that it can be successively exposed under various negatives, causing the sum of the parts shown on the negatives to become soluble. The result of the development is an anodised aluminium surface which is covered with a protective layer except on those parts where the contact elements are to be located. This surface is treated with a solution which removes the anodised layer but leaves the aluminium in its original state. An excellent solution for this purpose is a solution of sodium-dichromate and phosphoric acid in water at a temperature of about 90 degrees Celsius. This solution removes the anodised layer completely in those places where it is no longer covered by the photosensitive layer. As soon as the anodised layer has been removed from, and the aluminium surface is uncovered on these places, the plate is cleaned anew and is again anodised in a bath which affects the anodised layer while it is being produced. The effect on the newly anodised layer is the creation of pores. A suitable bath for this purpose is a 30 percent solution of phosphoric acid at a temperature of about 40 degrees Celsius. Actually this bath also affects the original anodised layer but because the porous anodised layer need only be a very thin one and the making of this porous layer consequently takes only a short time, the original anodised layer is only very slightly affected. The duration of this second anodising operation is such that a layer of the required thickness is manufactured. Generally the application of a phosphoric acid solution as electrolyte does not guarantee a sufficient porosity. For this reason it is desirable to leave the plate in the bath for a certain length of time after the current has been switched off. This substantially increases porosity. After the porous layer has been applied and the plate has been cleaned again, the metal for the contact elements is precipitated. This can be effected by electrolysis as well as by reduction. No metal will be precipitated during this operation on the original anodised layer because this layer is not, or at any rate only very slightly, porous. Plating will actually occur however, on the porous

anodised layers which cover the bottom of each of the openings in which contact elements must come. In this operation the pores are first closed, and then the plating spreads over the complete surface of the porous layer. Excellent results have been obtained with a plating of semi-bright nickel which has good qualities for this purpose. In the first place it has a good filling power for macroscopic unevennesses, thus promoting the flatness of the surfaces. Moreover it is a very tough material, providing practically undeformable contact elements. Nevertheless it is not as hard as bright nickel, which, because of its brittleness, has the disadvantage that it cannot sufficiently bridge the difference between its own expansion coefficient and that of the aluminium supporting layer, so that greater temperature changes will cause the nickel to separate from the supporting layer.

Electrical contact established with a nickel surface is not very reliable. Without any apparent reason the contact resistance of such a nickel contact may suddenly be increased. In connection therewith the nickel plating is so made that its upper surface is slightly below that of the anodised layer, and afterwards a layer of hard gold is precipitated, for instance electrolytically, on the nickel supporting surface. Hard gold is an excellent contact material and it is very resistant to wear so that a contact bank with hard gold contacts remains reliable for long periods of use. Preferably the layer of hard gold is made sufficiently thick that it slightly protrudes beyond the original anodised surface. After the precipitation of the gold the two surfaces are equalised by polishing or lapping, so that even the slightest unevenness near the boundary between a contact and the anodised layer is eliminated.

It is obvious that the various compositions of the baths are only mentioned as examples and that also other baths which have more or less the same effect can be applied. The same is valid for the dimensions and for the materials for the contact elements. It is, moreover, not absolutely necessary to connect the contact elements by means of a porous anodised layer to the supporting layer. Without such a porous anodised layer reasonable results may be obtained, but experience has shown that contact banks provided with such porous anodised layers are more reliable. The way in which the original aluminium surface has been planed is obviously of no importance. Moreover the aluminium surface need not be a part of an independent aluminium plate. As a matter of fact aluminium is not a very good construction material. It can be easily bent, and as soon as the surface layer has been removed, for instance in an effort to plane the plate, it will



in some cases become warped. In a very effective embodiment the aluminium surface is only part of an aluminium layer, such as an aluminium foil which is fixedly connected, for instance by bonding, to a plate of a stronger construction material, such as steel.

It would be possible to manufacture the contact elements completely from hard gold. Hard gold, however, is considerably more expensive than nickel, and although the quantity of the material used in one single contact bank is small, the economisation that can be reached by manufacturing only a part of each contact from hard gold may be considerable in the case of mass production of these contact banks.

In many applications the aluminium surface will be flat but in some applications it may be necessary to provide a curved surface for supporting the contact elements. In the former applications without special measures a flat negative can be used to form the pattern of contact element areas in the photosensitive layer.

What I claim is:

1. A switch contact bank comprising an aluminum surfaced support member having a plurality of electrically conductive contact elements thereon and an anodized layer on said support surface between adjacent individual contact elements, wherein said contact elements comprise a layer of nickel in deposited relation to said support member and a layer of gold in overlying deposited relation to said nickel layer.

2. A switch contact bank according to claim 1 wherein said contact element further comprises a porous anodized layer between said aluminum surface and said layer of nickel for mechanically and electrically connecting said layers.

3. A switch contact bank according to claim 2 in which said elements are arranged in concentric circular paths.

4. A switch contact bank according to claim 1 wherein the nickel layer of said contact element is semi-bright nickel.

5. A switch contact bank according to claim 2 wherein the surface of said contact elements and the surface of said anodized layer is flush.

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