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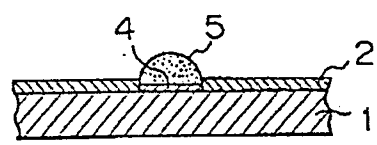
(54) **Electric contact member and method of making same.**

(57) An electric contact member comprising a thin sheet of a stainless steel and a projection of a tin-lead type solder formed on the surface of the thin sheet as a contacting portion is provided. The electric contact member is made by a process wherein a stainless steel sheet is printed with a resist paint of a desired pattern; the stainless steel sheet is optionally electroplated with nickel; the nickel-plated or non-plated stainless steel sheet is electroplated with gold, silver, palladium or their alloys; the electroplated stainless steel sheet is dipped in a bath of a tin-lead alloy solder melt whereby spot-like or stripe projections of the solder are formed on the stainless steel sheet; and then, the sheet is cut into electric contact members.

Fig. 3



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ELECTRIC CONTACT MEMBER AND METHOD OF MAKING SAME

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BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an electric contact member and a process for making it. More particularly, the present invention relates to an electric contact member comprising a contacting projection formed on a thin sheet of stainless steel, and a process for making it.

2. Description of the Prior Art

Movable contacts of keyboard switches or cameras have heretofore been formed by punching into predetermined sizes thin sheets of copper alloys such as phosphor bronze, nickel silver and beryllium copper. Recently, stainless steel thin sheets have also been proposed for use in these contact members.

In these electric contacts, the contacting sides are generally clad or deposited with gold, and in order to ensure the contacting function, conical projections having a diameter of 1 mm and a height of 0.15 mm are mechanically formed in the contacting portions of these metal sheets.

Gold is excellent in the corrosion resistance and has a good electrical conductivity and therefore, gold provides a contacting portion having a high reliability. However, gold is expensive.

Accordingly, trials have been made to reduce the amount used of gold. In the early stage, gold was clad in a thickness of 2 to 3 μm, but at the present, gold is clad or deposited in the form of a thin film having a thickness of up to about 1 μm or gold is clad or deposited only on a stripe-like restricted contacting portion.

An electric contact member is a very important element in an electronic machine, and is very broadly used in keyboard switches, computers, registers, telephone sets and calculators. Namely, electric contact members are manufactured as large-quantity parts and built in electronic machines.

The contacting portion is a most important part of an electric contact member, and this contacting portion should be composed of a metal having a low contact resistance, a high corrosion resistance and an excellent abrasion resistance. According to the standard of the abrasion resistance test for keyboards, the metal of the contacting portion should resist contacting under a pressing force of 20 g, which is repeated 10,000,000 times.

The minimum thickness of the gold film of the contacting portion, necessary for satisfying this requirement, is about 1 μm, and if the thickness of the gold film is smaller than about 1 μm, the substrate metal is exposed by abrasion of the gold film to cause corrosion and drastically increase the contact resistance, with the result that transmission of electric signals becomes inaccurate and the function of an electronic machine is lost.

SUMMARY OF THE INVENTION

It is a primary object of the present invention to provide a cheap electric contact member which comprises a contacting portion formed of a cheap metal and which has good electrical conductivity and corrosion resistance and can resist the switching operation repeated at a high frequency for a long time.

More specifically, in accordance with the present invention, there is provided an electric contact member comprising a thin sheet of a stainless steel and a projection of a tin-lead alloy solder formed on the surface of the thin sheet as a contacting portion.

BRIEF DESCRIPTION OF THE DRAWINGS

Figs. 1 through 3 are sectional views showing the steps of the process for forming an electric contact member according to the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The stainless steel is a metal having a good corrosion resistance and an excellent spring property, and the stainless steel is an effective material for an electric contact member. However, the stainless steel is defective in that the platability and solderability are poor.

The electric contact member of the present invention comprises a projection (contacting portion) of a tin-lead alloy solder formed on a stainless steel thin sheet, soldering of which has been considered difficult.

The solder constituting the contacting portion has the following composition:

Tin: 40 to 95% by weight
Lead: 5 to 60% by weight
Silver: 0 to 9.5% by weight
Antimony: 0 to 5% by weight
Bismuth: 0 to 5% by weight

Silver as one optional component of the solder exerts the function of increasing the hardness. Antimony as another optional component of the solder makes a contribution to enhancement of the dimension stability and bismuth as still another optional component makes a contribution to increase of the hardness.

The process for preparing the electric contact member of the present invention will now be described with reference to the accompanying drawings.

At first, a stainless steel hoop 1 is preliminarily printed with a resist paint 2, as shown in Fig. 1, so that a small circular non-printed portion 3 having a diameter of, for example, 1 mm is formed at a position where a contacting portion is to be formed, and such non-printed portions 3 are arranged at predetermined intervals. It is preferred that an ultraviolet ray-curable paint which is excellent in the chemical resistance and the high-temperature resistance and can be dried in a moment be used as the resist paint.

The non-printed portions 3 may be spot-like small circules arranged regularly as described above or they may be stripes.

A special preliminary treatment is carried out so that soldering becomes possible on the non-printed portions 3 distributed on the surface of the stainless steel hoop.

As is seen from its name, a special passivated film is formed on the surface of the stainless steel and this film prevents oxidation and controls occurrence of rusting. However, plating or soldering is impossible because of the presence of this film. Accordingly, in order to render soldering possible, it is first of all necessary to remove the passivated film.

In the present invention, only a passivated film is removed by alkali degreasing and activating treatments of the surface of the stainless steel sheet. The alkali degreasing treatment may be carried out according to the conventional method using a commercially available alkali degreasing solution. According to one preferred embodiment, the stainless steel sheet is dipped in a dilute solution of an alkali degreasing solution at an elevated temperature and electrolytic degreasing is then carried out in a dilute aqueous alkali solution.

After the alkali degreasing treatment, the stainless steel sheet is subjected to the activating treatment. It is preferred that this activating treatment be carried out in two stages. Namely, the activating treatment comprises the first step of dipping in an activating solution and the subsequent step of cathodic electrolysis in a cathodic electrolytic solution.

The activating solution used in the first activating treatment is preferably an aqueous mixed acid solution containing, based on the weight of the solution, (i) 3 to 20% by weight of hydrochloric acid, (ii) 2 to 30% by weight of sulfuric acid, (iii) 0.1 to 5% by weight of a nonionic, cationic or ampholytic surface active agent and (iv) 0.1 to 20% by weight of 2-pyrrolidone or its N-alkyl derivative such as N-ethyl-2-pyrrolidone or N-methyl-2-pyrrolidone.

The first activation treatment may be carried out by dipping the stainless steel sheet in the activating solution at a normal temperature for 30 seconds to 7 minutes, preferably under irradiation with ultrasonic waves.

The activated stainlees steel sheet is then subjected to the cathodic electrolytic activation. The cathodic electrolytic activation solution used is preferably an aqueous mixed acid solution containing, based on the weight of the solution, (i) 5 to 20% by weight of phosphoric acid, (ii) 2 to 10% by weight of nitric acid, (iii) 0.1 to 5% by weight of a nonionic cationic or ampholytic surface active agent and (iv) 0.1 to 20% by weight of 2-pyrrolidone or its N-alkyl derivative.

At the cathodic electrolytic activation step, the electrolysis may be carried out at a normal temperature to about 65°C at a cathode current density of 1 to 7 A/dm^2 for 30 seconds to 5 minutes by using a platinum-coated titanium anode and the stainless steel sheet as the cathode.

The stainless steel sheet which has been subjected to the activating treatment is then preferably subjected to nickel plating. This nickel plating is performed according to the conventional electrolytic plating method using nickel salts such as nickel sulfate, nickel sulfamate and nickel chloride. The nickel electroplating may be carried out at a temperature of 45 to 65°C in an electroplating solution at a cathode current density of 4 to 12 A/dm^2 for 10 seconds to 2 minutes by using the stainless steel sheet as the cathode and a nickel plate as the anode.

It is preferred that the amount deposited of nickel be so small that a color tone intermediate between the color tone before plating and the color tone of nickel is produced on the surface. Supposing that a uniform film of nickel is formed by plating (actually, no uniform film of nickel is formed because the amount deposited of nickel is very small), the amount of nickel is ordinarily controlled so that a film having a thickness of 100 to 1000 Å, preferably 300 to 700 Å, most preferably about 500 Å, is formed.

The stainless steel sheet which has been subjected to the activating treatment may be electroplated with gold, silver or palladium or an alloy thereof. If the stainless steel sheet is subjected to the nickel electroplating as mentioned above, the nickel-electroplated stainless steel sheet is immediately electroplated with gold, silver or palladium or an alloy thereof. The electroplating procedure may be conventional. Usually, the electroplating is carried out at a temperature of 20 to 65°C at a cathode current density of 0.5 to 18 A/dm^2 for one second to two minutes by using the stainless steel sheet as the cathode and a nickel plate as the anode. The electroplating of gold may be carried out preferably by using an electroplating solution containing about 80 to 140 g/ℓ of citric acid, about 80 to 140 g/ℓ of sodium citrate, about 15 to 40 g/ℓ of nickel sulfamate and about 4 to 10 g/ℓ of potassium gold cyanide and maintained at a temperature of 40 to 65°C. The electroplating of silver or palladium is preferably carried out at a temperature of 20 to 30°C.

The amount deposited of gold, silver, palladium or an alloy thereof is important in the present invention. Namely, the amount deposited is so small that a color tone intermediate between the color tone before plating and the color tone of gold, silver, palladium or an alloy thereof is produced on the plated surface. Supposing that a uniform film of the metal or alloy is formed by plating, the amount deposited of the metal or alloy is controlled so that the thickness of the gold or palladium film is 30 to 500 Å, preferably 50 to 300 Å, and the thickness of the silver film is 50 to 2000 Å, preferably 100 to 1000 Å (actually, no uniform film is formed but the metal or alloy is deposited in the form of spots).

When the thus-obtained stainless steel hoop 1 which has been printed with the resist paint 2 and on which the underground plating 4 for soldering has been formed is passed through a bath of a soldering melt set at a temperature of 230 to 250°C, conical projections 5 of a solder having a diameter of 1 mm and a height of 0.12 to 0.15 mm are continuously formed on the surface of the stainless steel hoop 1 in a moment, as shown in Fig. 3, whereby the contacting portion of the electric contact member of the present invention is formed.

According to the intended use, the resist paint 2 is removed from the thus-obtained stainless steel plate to expose the texture of the stainless steel sheet 1 and the sheet is then subjected to the punching operation. When the insulating function of this resist paint is utilized, the paint is not peeled but the stainless steel sheet 1 is directly subjected to the punching operation and built as a contacting portion into an electronic machine.

According to the above-mentioned process, contacting portions of a solder can be easily formed in an optional shape and arrangement on the stainless steel sheet by changing the printing pattern.

Since the contacting portion of the electric contact member obtained by punching the stainless steel sheet having projections of a solder is formed of a cheap alloy solder, according to the present invention, the cost of electric contacts such as keyboard contacts or movable contacts of cameras, which are used in large quantities in the field of electronic industry, can be greatly reduced.

The present invention will now be described in detail with reference to the following examples.

Example 1

A stainless steel hoop of SUS-304 having a thickness of 0.1 mm, a width of 10 mm and a length of 1200 m was subjected to partial soldering for forming contacting portions through the following steps.

(1) Masking Printing Step

The stainless steel hoop was mask-printed with an ultraviolet ray-curable resist paint so that circular non-printed portions having a diameter of 1.5 mm were formed at intervals of 14 mm in the central portion of the stainless steel hoop, and the back surface was entirely printed.

(2) Alkali Electrolytic Degreasing Step

A commercially available alkali degreasing solution was heated at 70 to 80°C in a stainless steel tank, and the stainless steel hoop was passed through the degreasing solution in the tank in succession to effect the primary degreasing. Then, in the alkali degreasing solution maintained at 40 to 60°C, direct current electrolytic degreasing was carried out by applying a voltage of 6 volts and using a stainless steel sheet as the anode and the above-mentioned stainless steel hoop as the cathode.

(3) First Activation Treatment Step

Then, the stainless steel hoop was passed through an activating solution formed by adding 0.2% by weight of a nonionic surface active agent such as polyethylene glycol alkyl ether or polyethylene glycol fatty acid ester or an amphoteric surface active agent and 0.1% by weight of an amine type anti-corrosive agent (Armohiboo 28 supplied by Lion-Armar Co.) to a mixed

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acid comprising 20% by volume of hydrochloric acid (35% solution), 10% by volume of sulfuric acid (85% solution), 10% by weight of citric acid (powder), 1% by volume of acetic acid (90% solution), 5% by volume of nitric acid (68% solution) and 5% by weight of N-methyl-2-pyrrolidone under irradiation with ultrasonic waves of 600 W, whereby the oxides and impurities were removed from the non-printed portions of the stainless steel hoop.

(4) Cathodic Electrolytic Activation Step

A solution formed by adding 0.2% by weight of the same nonionic or amphoteric surface active agent as described above and 0.1% by weight of the same anti-corrosive agent as described above to a mixed acid comprising 10% by volume of phosphoric acid (85% solution), 10% by volume of sulfuric acid (85% solution), 10% by volume of nitric acid (70% solution), 5% by weight of citric acid (powder), 1% by volume of acetic acid (90% solution) and 5% by weight of N-methyl-2-pyrrolidone was heated at 60°C, and the stainless steel hoop was passed through the solution by applying a voltage of 4 volts between the stainless steel hoop as the cathode and a platinum-deposited titanium plate as the anode, whereby the non-printed portions of the stainless steel hoop were activated.

(5) Gold Plating Step

Gold plating was carried out for 3 seconds in a plating solution comprising 120 g/ℓ citric acid, 120 g/ℓ of sodium citrate, 30 g/ℓ of nickel sulfamate and 8 g/ℓ of potassium gold cyanide at a current density of 10 to 3 A/dm^2 at a plating solution temperature of 35°C by using the stainless steel hoop as the cathode and a platinum-plated titanium plate as the anode.

A gold-nickel alloy layer having a thickness of 0.01 μm was formed as an underground plating layer for soldering on the non-printing portions of the stainless steel hoop.

(6) Soldering Step

A solder comprising 60% of tin, 36% of lead, 2% of silver and 2% of antimony was melted at 230°C in a soldering tank, and the stainless steel hoop was passed through the soldering tank for an immersion time of 3 seconds, whereby a stainless steel hoop having conical projections of the solder having a bottom diameter of 1.5 mm and a central height of 0.12 mm, as contacting portions arranged continuously, was obtained.

Example 2

A stainless steel hoop of SUS-304 having a thickness of 0.15 mm, a width of 15 mm and a length of 700 mm was subjected to partial soldering for forming contacting portions through the following steps.

(1) Pressing Step

The stainless steel hoop was subjected to the pressing operation using a mold so that recesses having a width of 2 mm, a length of 5 mm and a depth of 0.1 mm were formed at intervals of 10 mm in the central portion of the stainless steel hoop.

(2) Masking Printing Step

The stainless steel hoop from the step (1) was continuously mask-printed with an ultraviolet ray-curable resist paint so that only the inner faces of the recesses having a width of 2 m and a length of 5 mm were formed into non-printed portions, and the back surface of the stainless steel hoop was entirely printed.

(3) Alkali Electrolytic Degreasing Step

The alkali electric degreasing treatment was carried out in the same manner as described in Example 1.

(4) First Activation Treatment Step

The first activation treatment was carried out in the same manner as described in Example 1.

(5) Cathodic Electrolytic Activation Treatment Step

The cathodic electrolytic activation treatment was carried out in the same manner as described in Example 1.

(6) Nickel Plating Step

Flash plating was carried out at a current density of 6 A/dm^2 for 15 seconds at a plating solution temperature of 50°C in a plating solution comprising 300 g/ℓ of nickel sulfate, 40 g/ℓ of nickel chloride and 30 g/ℓ of boric acid by using the stainless steel hoop as the cathode and a nickel plate as the anode.

(7) Gold Nickel Alloy Plating step

Plating was carried out at a current density of 10 to 3 A/dm^2 for 2 seconds at a plating solution temperature of 45°C in a plating solutiom comprising 120 g/ℓ of citric acid, 120 g/ℓ of sodium citrate, 30 g/ℓ of nickel sulfamate and 8 g/ℓ of potassium gold cyanide by using the stainless steel hoop as the cathode and a platinum-deposited titanium sheet as the anode.

A gold-nickel alloy plating layer having a thickness of 0.007 μm was thus formed as an undercoating layer for soldering in the non-printed portions of the stainless steel hoop.

(8) Paint-Peelling Step

The stainless steel hoop was passed through a solution comprising 40% of methylene dichloride and 3% of formic acid and maintained at 35°C for an immersion time of 30 seconds, whereby the ultraviolet ray-curable resist paint was peeld.

(9) Soldering Step

A solder comprising 88% of tin, 2% of silver, 10% of lead and 2% of antimony was melted at 240°C in a soldering tank, and the stainless steel hoop was passed through the soldering tank for an immersion time of 3 seconds, whereby a stainless steel hoop having contacting portions having a thickness of 0.16 to 0.2 mm, which were continuously formed only on the recesses having a width of 2 mm, a length of 5 mm and a depth of 0.1 mm,

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was obtained.

The projecting contacting portions of the silver-incorporated alloy solder of the stainless steel hoop prepared through the above-mentioned steps had excellent properties described below.

(A) Electrical Conductivity

The electrical conductivity of the contacting poriton of the silver-incorporated alloy solder corresponded to about 14% of the electric conductivity of copper, which was substantially equal to the electric conductivity of iron corresponding to 14.8% of the electrical conductivity of copper. Thus, it was confirmed that the contact portion could be effectively used as an electric contact.

(B) Hardness

The contacting portion had a Vickers hardness of about 42, which is higher than the Vickers hardness of pure gold (25) but lower than the Vickers hardness of a gold-nickel alloy plating (about 120). Although the allowable thickness of the gold-nickel plating layer is about 1 μm, the solder layer of the present invention can be applied in a thickness of 30 to 100 μm to the contacting portion, whereby the contacting portion which is excellent in the abrasion resistance over the conventional gold-clad or gold-plated contacting portion can be formed.

CLAIMS

1. An electric contact member comprising a thin sheet of a stainless steel and a projection of a tin-lead alloy solder formed on the surface of the thin sheet as a contacting portion.

2. An electric contact member according to claim 1, wherein said electric contact member is made by cutting a thin stailess steel sheet having projections of the tin-lead alloy solder in the form of spots.

3. An electric contact member according to claim 1, wherein said electric contact member is made by cutting a thin stainless steel sheet having projections of the tin-lead alloy solder in the form of stripes.

4. An electric contact member according to claim 1, wherein an ultra-thin plating layer of a metal selected from the group consisting of gold, silver and palladium, or an alloy selected from the group consisting of gold-, silver- or palladium-containing alloys is formed between the stainless steel sheet and the tin-lead type solder projection.

5. A process for making an electric contact member comprising a thin sheet of a stainless steel and a projection of a tin-lead alloy solder formed on the surface of the thin sheet as a contacting portion, which comprises the steps of:

printing a stainless steel sheet with a resist paint having a desired pattern,

electroplating the stainless steel sheet wiht a metal selected from the group consisting of gold, silver and palladium, and alloys of these metals,

dipping the electroplated stainless steel sheet in a bath of a tin-lead alloy solder melt whereby projections of the tin-lead type solder in the form of spots or stripes are formed on the stainless steel sheet, and then

cutting the stailess steel sheet into electric contact members.

6. A process according to calim 5, wherein the electroplating of the resist-formed stainless steel sheet is carried out to an extent such that the resulting plated stainless steel exhibits a color tone intermediate between the color tone of the unelectroplated stainless steel and the color tone of the gold, silver, palladium or alloy thereof used.

7. A process according to the claim 5, wherein, prior to the electroplating with gold, silver, palladium or their alloys, the resist-formed stainless steel sheet is electroplated with nickel.

8. A process according to claim 7, wherein the electroplating with nickel is carried out to an extent such that the resulting nickel-plating stainless steel exhibits a color tone intermediate between the color tone of the unelectroplated stainless steel and the color tone of nickel.

Fig. 1

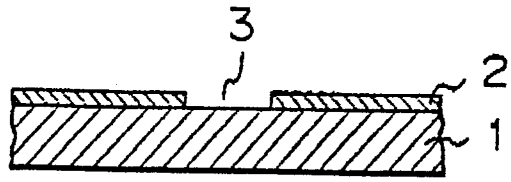

Fig. 2

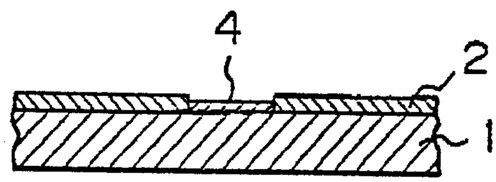

Fig. 3