United States Patent

Penczek

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[45] **June 20, 1972**

[54] **AN ELECTRICAL CONTACT STRUCTURE FOR A SWITCH REED COMPRISING GOLD AND PALLADIUM LAYERS**

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[21] Appl. No.: **124,312**

[52] **U.S. Cl.** .... **200/166 C,** 29/630 C

[51] **Int. Cl.** **H01h 1/02**

[58] **Field of Search** .... 200/166 C; 29/630 C

[56] **References Cited**

UNITED STATES PATENTS

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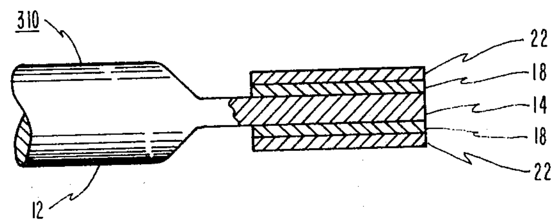
[57] **ABSTRACT**

A switch reed embodies an electrical contact comprising a plurality of layers of electrical contact material disposed on at least one surface of a flattened portion of the reed. A layer of gold of the contact is disposed on the reed surface and at least one of the other layers comprising the contact is of palladium metal.

11 Claims, 6 Drawing Figures



Patented June 20, 1972

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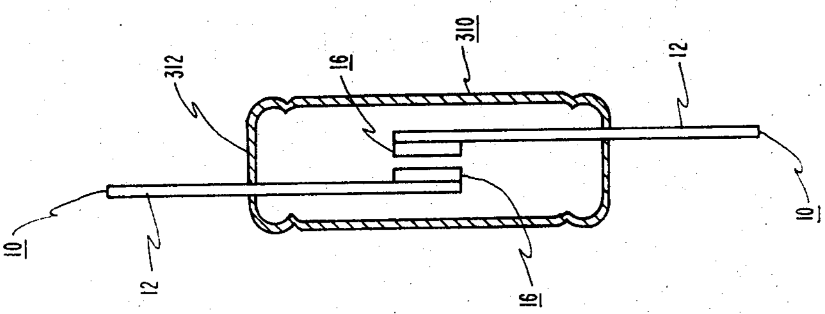

Fig. 5

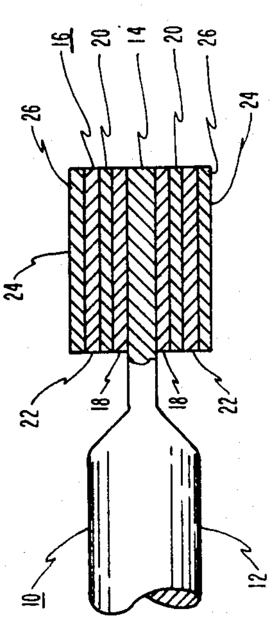

Fig. 1

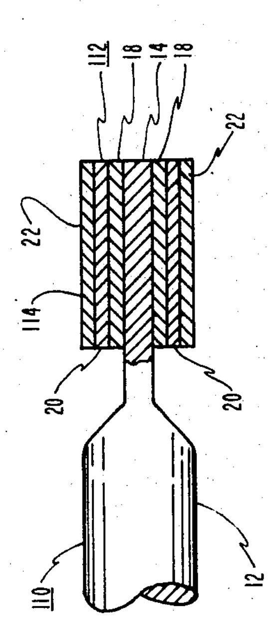

Fig. 3

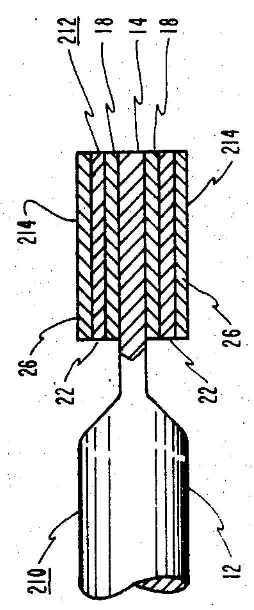

Fig. 4

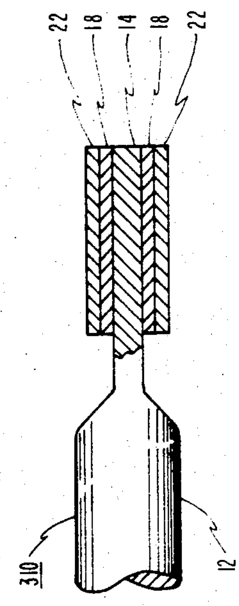

Fig. 6

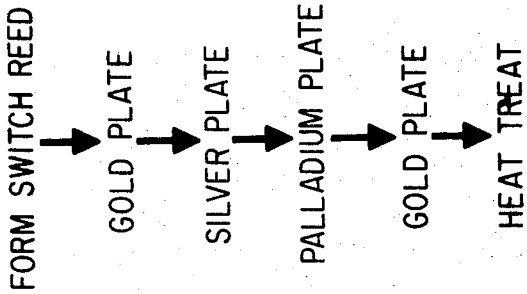

Fig. 2

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ELECTRICAL CONTACT STRUCTURE FOR A SWITCH REED COMPRISING GOLD AND PALLADIUM LAYERS

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to switch reeds in general and, in particular, to the structure of an electrical contact comprising a part of the reed.

2. Description of the Prior Art

Prior art switch reeds prematurely fail because of peak cone metal transfer which occurs between opposing electrical contacts of reeds due to arching during the normal operational life or a reed switch assembly. When peak cone metal transfer becomes excessive, the opposed contacts seize or lock together causing the switch assembly to prematurely fail causing a short circuit. Often this occurs prior to the completion of less than 2,000,000 cycles of opening and closing of contacts of a switch assembly during a standard life test required for telephone switching acceptance. Prior art switches embodying palladium as an initial layer of electrical contact metal to prevent diffusion of iron into the electrical contact of the reed have not been able to extend the life of contacts sufficiently to consistently pass the required life test.

An object of this invention is to provide a new and improved electrical contact for a switch reed to minimize or eliminate peak cone metal transfer during operation of a switch assembly embodying the reed.

Another object of this invention is to provide a new and improved electrical contact for a switch reed for use in a switch assembly comprising a plurality of layers of electrical contact metals wherein a layer of gold is initially disposed on the material comprising the reed and one of the other layers is of palladium metal.

A further object of this invention is to provide a new and improved non-binding electrical contact for a switch reed wherein metal transfer between opposed contacts of a switch assembly imparts a dome shape configuration to the electrical contact.

SUMMARY OF THE INVENTION

In accordance with the teachings of this invention, there is provided a switch reed comprising a body of electrically conductive magnetic material. The switch reed has at least an integral flattened end portion. A plurality of layers of electrical contact metals comprise an electrical contact affixed in an electrically conductive relationship to at least a part of one surface of the flattened end portion. The contact comprises at least a layer of gold affixed to at least a part of the one surface of the flattened end portion and one of the other layers comprises palladium metal.

DESCRIPTION OF THE DRAWINGS

FIG. **1** is an elevation view, partly in cross section, of a switch reed made in accordance with the teachings of this invention;

FIG. **2** is a flow diagram of a process for making the electrical contact of the switch reed of Fig. **1**;

FIG. **3** is an elevation view, partly in cross section, of an alternate embodiment of the switch reed of Fig. **1**, and

FIG. **4** is an elevation view, partly in cross section, of another alternate embodiment of the switch reed of Fig. **1**;

FIG. **5** is an elevation view, partly in cross-section, of a reed switch assembly made in accordance with the teachings of this invention, and FIG. **6** is an elevation view, partly in cross-section, of another alternate embodiment of the switch reed of Fig. **1**.

DESCRIPTION OF THE INVENTION

With reference to Figs. **1** and **2**, there is shown a preferred embodiment of a switch reed **10** made in accordance with the teachings of the invention. The reed **10** comprises a cylindrical member **12** and a flat end portion **14**. Preferably, the flattened portion **14** is integral with the member **12** and the reed **10** is made from wire stock by such suitable means as a punch press or a multislide. The end portion **14** is preferably formed by cold working and provides a stiff structure for subsequent processing operations. The stiff structure reduces the rejection of reeds **10** due to malformed or damaged end portions **14**.

The reed **10** preferably comprises a magnetic material such, for example, as a nickel-iron alloy. Suitable nickel-iron alloys comprise **51** percent by weight of nickel and the remainder iron, and **52** percent by weight nickel and the remainder iron.

An electrical contact **16** comprising a plurality of layers of electrically conductive material is disposed on at least a part of one surface of the end portion **14**. After fabrication, the reed **10** is degreased, cleaned, and plated to form the contact **16** with a first layer **18** of gold. The thickness of the layer **18** is from 0.000020 inch to 0.000060 inch. A thickness of approximately 0.000045 inch is preferred for the gold layer **18**. The layer **18** of gold provides a basis for an efficient electrical contact to the reed **10**.

After rinsing in clear running water, a layer **20** of silver is disposed on the layer **18** of gold. The layer **20** is from 0.000005 inch to 0.000020 inch in thickness. A preferred thickness of the layer **20** is approximately 0.000010 inch. Although not required, the layer **20** of silver enables silver to diffuse into the layer **18** of gold to provide a hardened wear resistant electrical contact.

The reed **10** and the plated layers **18** and **20** are rinsed in clear running water and a layer **22** of palladium is disposed on the layer **20** of silver. The thickness of the layer **22** is from 0.000015 inch to 0.000120 inch. A preferred thickness is approximately 0.000005 inch. The layer of palladium appears to prevent iron of the material comprising the reed **10** from diffusing through the plurality of layers to the top surface **24** of the contact **16**. This prevents the top surface **24** from being degraded electrically because of contamination by less electrically conductive material contained therein.

The plated reed **10** is again rinsed in clear running water and a second layer **26** of gold is disposed on the layer **22** of palladium. The thickness of the layer **26** is from 0.000005 inch to 0.000030 inch. A preferred thickness is approximately 0.000010 inch. The layer **26** of gold provides an excellent electrically conductive contact surface which is quite resistant to oxidation.

After formation of the layer **26**, the processed reed **10** is rinsed in clear running water, and preferably, rinsed a second time in deionized water, dried and then heat treated. The processed reed **10** is heated to a temperature of from **1,450°** to **1,650°** F. for a sufficient time to diffuse the metals of the plurality of layers of the contact **16** into one another as well as to stress relieve the end portion **14**. A sufficient time is provided during heat treatment to provide a preheat cycle to bake the plated areas. Baking of the plated areas enables any entrapped gases within the plated layers to be spilled without causing flaking of the plated metals or separation of the plated layers from each other or the member. Stress relieving the end portion **14** restores substantially all of the flexibility of the portion **14** inherent of the material comprising the reed **10**. A preferred heat treat temperature is **1,650° ± 15°** F. for a time at temperature of from 15 to 20 minutes. Heat treating is preferably accomplished in an inert or a reducing atmosphere such, for example, as in hydrogen, nitrogen, argon and helium.

As a result of the heat treatment at least a portion of the material comprising the plurality of layers of the contact **16** diffuse into one another. Additionally, some iron diffuses into the layers **18** and **20** from the end portion **14**. The exact composition and resulting structure of the contact **16** after heat treatment is unknown. It is known that after heat treatment the yellow color of the layer **26** is replaced by a yellow-white or substantially white coloration.

The resultant contact **16** forms an excellent electrically conductive contact. The surface **24** exhibits excellent wear resistance. Any metal transfer which occurs between the opposed surfaces **24** of two switch reeds **10** employed in a switch reed assembly is of a dome-like configuration. Repeated life cycle tests of reeds **10** made in accordance with the teachings of this invention exceed the minimum of 2,000,000 cycles of a life test without the opposed contacts **16** seizing and locking together.

With reference to Fig. **3**, there is shown a switch reed **110** which is an alternate embodiment of the reed **10**. An item denoted by the same reference numeral in Fig. **2**, as in Fig. **1**, is the same item in every respect as in Fig. **1**. The reed **110** comprises an electrical contact **112** comprising a plurality of electrical contact metals. The contact **112**, before heat treatment, comprises the layers **18**, **20** and **22** of gold, silver and palladium, respectively.

After heat treatment it is found that the contact **112** is an excellent electrical contact and performs as well as the contact **16** of reed **10**. The contact **112** has a top surface **114** which provides an excellent wear resistant surface for the contact **112**.

Referring now to Fig. **4**, there is shown a switch reed **210** which is another embodiment of the switch reed **10**. The items denoted by the reference numerals as shown in Fig. **4** are exactly the same, and function in the same manner, as the items having the same reference numerals in the Fig. **1**.

The reed **210** comprises a contact **212** disposed on at least a part of one surface of the end portion **14**. The contact **212** comprises the plurality of layers of the same electrical contact materials as the contact **16** of reed **10**, except no layer of silver is present. After the same heat treatment as the reed **10**, the reed **210** functions electrically and mechanically as well as the reed **10**. The contact **212** has a top surface **214** which shows excellent wear resistance.

With reference to Fig. **6**, there is shown a switch reed **310** which is another embodiment of the switch reed **10**. The items denoted by the reference numerals as shown in Fig. **6** are exactly the same, and function in the same manner, as the items having the same reference numerals in Fig. **1**.

The switch reed **310** comprises a contact disposed on at least a part of one surface of the end portion **14**. The contact comprises only the layer **18** of gold disposed on the portion of the surface of the end portion **14** and a layer **22** of palladium disposed on the layer of gold. After the same heat treatment process as the switch reed **10**, the switch reed **310** functions as well electrically and mechanically as the switch reed **10**.

With reference now to Fig. **5**, there is shown a reed switch assembly **310** comprising two switch reeds **10**. That portion of each of the reeds **10** which comprises the contact **16** is sealed within an envelope **312** containing a substantially inert atmosphere. Suitable materials for comprising the atmosphere of the envelope **312** are hydrogen, nitrogen, argon and a forming gas such, for example, as one comprising 97 percent by volume nitrogen and 3 percent by volume hydrogen. A portion of the member **12** of each reed **10** protrudes outside the envelope **312** and enables an electrical connection to be made thereto for each reed **10**. A magnetic flux field is created about one or both switch reeds **10** and the contacts **16** are attracted to each other. Upon making an abutting contact with each other, an electrical connection between the two switch reeds **10** is completed and the associated electrical leads connected thereto. Removal of the magnetic field of flux from one, or both, of the reeds **10** causes the contacts **16** to separate from each other. The assembly **310** is suitable for use in telephone switching equipment and the like.

To illustrate the teachings of this invention, a switch reed, as shown in Fig. **1**, was made in accordance with the teachings of this invention and was tested, evaluated, and the results compared with those of prior art switch reeds in the following manner:

EXAMPLE I

Switch reeds comprising a magnetic material comprising 52 percent nickel and the remainder iron were manufactured on a multislide machine. The configuration before plating of an electrical contact on the flat end portion was as shown in Figs. **1** through **3**. The flat end portion after forming was quite stiff and inflexible. The reeds were ultrasonically degreased in Freon TF and rinsed in clear Freon TF. The last three-sixteenths of an inch of the flattened portion of each reed was then cleaned by soaking in an aqueons solution Metex E–**1736** and rinsed in water. The cleaned end portions were then cleaned anodicaly for one minute at 5 volts d.c. in an alkaline solution having a temperature of from 120°–140° F. The end portions up to a minimum height of five-sixteenths of an inch from the end were rinsed in clean running water. The cleaned end portions were neutralized in 30 percent by volume of reagent grade hydrochloric acid to a distance of one-fourth of an inch from the end of each flattened portion and rinsed in clean running water.

Each reed was plated with gold to a distance of three-sixteenths of an inch from the end of the flat end portion. The agitated gold solution contained from 0.9 to 2.0 troy ounces of gold per gallon and had a PH of approximately 5.75, a temperature of from 120° to 140° F. and a specific gravity of about 15° Baume. Plating time was 8-½ minutes at 700 milliamperes. The reeds were then rinsed in clear running water.

The reeds were then plated with silver to a distance of one-eighth of an inch from the end of the flat end portion of each reed. The silver solution contained 3.5 troy ounces of silver per gallon and had a PH of approximately 12.5. The plating time was 15 seconds at 3,000 milliamperes. The plated reeds were rinsed in clear running water.

The reeds were then plated with palladium to a distance of one-eighth of an inch from the end of the flattened portion of each reed. The palladium solution contained 5 grams of palladium per liter and had a temperature of 125° F. and a PH of approximately 8.5. The plating time was 15 minutes at 900 milliamperes. The plated reeds were then rinsed in clean running water.

The reeds were again gold plated. However, the plating distance was only one-eighth of an inch from the end of the flattened portion and the plating time was only approximately 3 minutes. The plated reeds were rinsed in clean running water initially. The reeds were rinsed a second time in deionized water and dried at approximately 320° ± 10° F. in a circulating air furnace.

Upon cooling to room temperature, the plated reeds were examined visually. The plated end portions had a yellow appearance of gold. Several reeds were sectioned, mounted and examined. The plated areas were clearly visible. The first gold layer had an average thickness of about 0.000045 of an inch. The average thickness of the silver layer was about 0.000010 of an inch. The average thickness of the palladium layer was about 0.000005. The second gold layer had an average thickness of about 0.000015 of an inch.

The remaining plated reeds were heated to a temperature of about 1,650° ± 15° F. for from 15 to 20 minutes at temperature. Heat treating was done in an atmosphere of hydrogen having a dew point of –50° C. and a flow rate of 15 cubic feet per hour. The reeds were cooled to room temperature in flowing hydrogen gas.

A visual examination of the reeds showed the plated flat end portion to have a white or whitish yellow color. The flat end portion of each reed was quite more flexible when compared to their flexibility after forming and before plating. Several reeds were sectioned and the plated end portions examined at a magnification of 1,500X. The stratification of the plated layers was less decernable than before heat treatment. Diffusion of metals from the layers into one another had occurred. Further examination indicated that no iron had diffused past the initial layer of palladium.

The remaining reeds were then mounted in a life test fixtured and cycled at 20 cycles per second to evaluate the plated contact of the flat end portion. The test duplicated normal contact operation of making and breaking at 50 volts and 0.070 ampere. A completion of a minimum of 2,000,000 cycles is required to be acceptable for telephony equipment.

All of the plated reeds exceeded 10,000,000 cycles without failure. No seizing of opposed contacts occurred to cause bridging and shorting out the circuit. Examination showed the surfaces of the contacts to exhibit excellent wear resistance. Metal transfer between two contacts of the same configuration and made in accordance with the teachings of this invention was of a dome-like configuration.

One group of prior art reeds, each having an electrical contact comprising layers of gold, silver and gold metals disposed one upon the other were life cycled in the same manner as the above plated reeds of this invention. The reeds failed before 2,000,000 cycles because of high contact resistance.

A second group of prior art reeds, each having an electrical contact comprising layers of palladium, gold, silver and gold metals disposed one upon the other were life cycled in the same manner as the plated reeds of this invention. The prior art reeds failed by seizing before 2,000,000 cycles had been completed. A peak cone transfer of metal between two opposed contacts caused a direct short circuit between the opposed contacts.

EXAMPLE II

Switch reeds were made in the same manner as those of Example I except that the silver plating was omitted.

The physical features of the plated reeds before and after heat treatment were the same as those of Example I, except no silver was present.

All the plated reeds exceeded 2,000,000 cycles of the life test. The contact surface showed excellent resistance to wear and a dome-like transfer of metal had occurred. No reeds failed because of seizing.

EXAMPLE III

Switch reeds were made in the same manner as those of Example I, except that the second layer of gold was omitted.

The physical features of the plated reeds, except for color and the absence of the second gold layer, was exactly the same as for those reeds of Example I both before and after heat treatment.

Switch reeds made in accordance with this invention are therefore excellent reed components for reed switch assemblies. Whereas, some prior art assemblies required opposed electrical contacts to be of dissimilar metals, a reed switch assembly of this invention utilizes the same electrical contact metal structure for the switch reeds. This eliminates the requirement of two different components and optimizes production capabilities and results in a superior reed switch assembly of greater reliability.

What is claimed is:

1. A switch reed comprising:

a. a body of electrically conductive magnetic material having at least an integral flat end portion; and

b. an electrical contact disposed on, and in an electrical conductive relationship with at least a part of one of the surfaces of the flat end portion and initially comprising before heat treatment, a plurality of layers of electrically conductive metals disposed one upon the other including;

a layer of gold disposed on at least one surface of a part of the flattened end portion, and

a layer of palladium.

2. The switch reed of claim 1 and including:

a layer of silver disposed between and in abutting electrical contact with, said layers of gold and palladium.

3. The switch reed of claim 2 wherein:

said layer of gold has an initial thickness of from 0.000020 to 0.000060 inch;

said layer of silver has an initial thickness of from 0.00005 to 0.000020 inch, and

said layer of palladium has an initial thickness of from 0.000015 to 0.000120.

4. The switch reed of claim 2 wherein:

the layer of gold has an initial thickness of approximately 0.000045 inch;

the layer of silver has an initial thickness of approximately 0.000010 inch, and

the layer of palladium as an initial thickness of approximately 0.00005 inch.

5. The switch reed of claim 2 including:

a layer of gold disposed on said layer of palladium.

6. The switch reed of claim 3 including:

a layer of gold of from 0.00005 inch to 0.000030 inch in thickness initially disposed on said layer of palladium.

7. The switch reed of claim 6 wherein:

the layer of gold on said layer of palladium is approximately 0.000015 inch in thickness initially.

8. A reed switch assembly comprising:

an envelope, and

a pair of switch reeds, each reed comprising a body of electrically conductive magnetic material having at least an integral flattened end portion, an electrical contact disposed on, and in an electrical conductive relationship with at least a part of one of the surfaces of the flattened portion and initially comprising, before heat treatment, a plurality of electrically conductive metal layers disposed one upon the other and comprising at least a layer of gold disposed on at least one surface of a part of the flattened end portion and a layer of palladium, the flattened portion of each switch reed being incorporated within said envelope and spaced apart from the other flattened portion, the contacts of said reeds being disposed spaced apart and opposed to one another.

9. The reed switch assembly of claim 8 in which said contact comprises:

a layer of silver disposed between and in abutting electrical contact with said layers of gold and palladium; and

said layers of gold has an initial thickness of from 0.000020 to 0.000060 inch;

said layer of silver has an initial thickness of from 0.000005 to 0.000020 inch, and

said layer of palladium has an initial thickness of from 0.000015 to 0.000120 inch.

10. The reed switch assembly of claim 9 in which:

said contact comprises a second layer of gold disposed on, and is an electrically conductive relationship with, said layer of palladium, said layer of gold having an initial thickness of from 0.000005 inch to 0.000030 inch.

11. The reed switch assembly of claim 10 in which:

said layer of gold initially has a thickness of approximately 0.000045 inch;

said layer of silver initially has a thickness of approximately 0.000010 inch;

said layer of palladium has an initial thickness of approximately 0.00005 inch, and

said second layer of gold has an initial thickness of approximately 0.000015 inch.

* * * * *

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 3,671,702
DATED : June 20, 1972
INVENTOR(S) : Edward S. Penczek

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Col 2, line 34 "0.000005" should be ---0.00005---.

Col 4, line 57 "0.000005" should be ---0.00005---.

Signed and Sealed this

twenty-first Day of *October 1975*

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks