

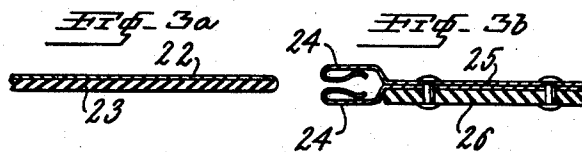
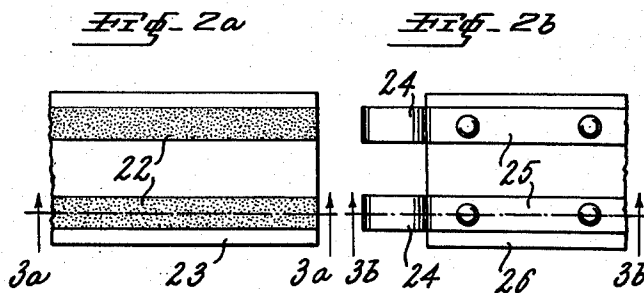
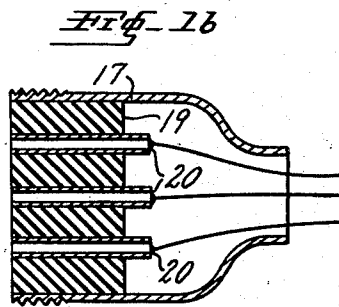
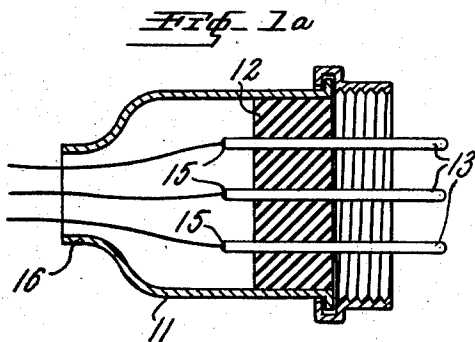
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D. G. GRABBE

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ELECTRICAL CONNECTOR

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INVENTOR
DIMITRY GRABBE

BY *Charles A. Blank*
ATTORNEY

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3,175,181

ELECTRICAL CONNECTOR

Dimiáry G. Grabbe, Sea Cliff, N.Y., assignor, by mesne assignments, to Photocircuits Corporation, Glen Cove, N.Y., a corporation of New York

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This invention relates to electrical connectors and, more particularly, to connectors which may be readily attached to and detached from mating connectors.

For example, the connectors may be of a multiple pin type for insertion in a suitable receptacle commonly utilized to interconnect cable harnesses, or the connectors may be of a finger-edge slidable type ordinarily utilized to interconnect printed circuits.

It is desirable that an electrical connector be corrosive-resistant, have low electrical resistance and a long life permitting a substantial number of reinsertions of the connector without affecting its electrical characteristics. Some prior connectors have been made by electrodepositing metallic coatings over a body or base material. For example, silver with a gold flash may be deposited over nickel or over beryllium-copper or over phosphor-bronze. The electrodeposition of the coating introduces a problem since hydrogen and hydroxides are deposited from the plating solution in addition to the metal. Some of the hydrogen becomes entrapped in the electrodeposited coating and some hydrogen becomes chemically bonded. Accordingly, in the presence of humidity, local electric cells develop within the metals of the connector pins because the metals have a different position in the electromotive series. The action of the local cells results in corrosion. The corrosion products are sometimes semiconductors and sometimes insulators. The corrosion products grow volumetrically due to the fact that the molecule of the oxide or other compound is larger than the unit cell of the body material. The growth of the compound forces the two contacting metallic members apart, thus making an open contact or a high resistance noisy junction. Accordingly, connector pins made by electrodeposition techniques are not entirely satisfactory for some applications.

Another type of connector for use with printed circuits utilizes a pure gold rivet which contacts a printed circuit conductor at a substantial pressure. The printed circuit conductor is plated with gold over nickel over copper, and as the electroplated gold wears out, gold is transferred from the gold rivet to the nickel coating. This is due to the Thompson effect which occurs when two metallic members sliding on each other under pressure exceed the elastic limit of the material of the sliding metallic members, causing the protective oxide coating on the metal to fracture and thereby establishing a metal-to-metal contact and welding of the two members at the interface. As the members continue to slide on each other, the welded intersection breaks but it breaks at a point other than the interface because the contacting surface layers of the metal have been work-hardened and possess a greater tensile strength than the bulk of the material. Accordingly a metal transfer occurs. Thus, the gold rivet is eventually worn out.

The use of solid gold for the body material of the printed circuit conductor is prohibitive from a cost standpoint.

It is an object of the present invention, therefore, to provide a new and improved electrical connector which is corrosive-resistant, has a long life, and a low electrical resistance.

It is an other object of the invention to provide a new and improved electrical connector which utilizes an inexpensive body material and which is corrosive-resistant.

In accordance with the invention, a detachable electrical connector comprises an electrical contact member adapted

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for detachable interconnection with a mating member. At least the contact surface of the contact member comprises an alloy of at least one member selected from the group consisting essentially of indium, gallium, indium alloy and gallium alloys.

For a better understanding of the present invention, together with other and further objects thereof, reference is made to the following description, taken in connection with the accompanying drawing, and its scope will be pointed out in the appended claims.

Referring to the drawing:

FIGS. 1a and 1b are views in section of pin-type mating connectors constructed in accordance with the invention;

FIGS. 2a and 2b are plan views of sliding contact mating connectors suitable for use with printed circuits and constructed in accordance with the present invention; and

FIGS. 3a and 3b are views in section of the connectors of FIGS. 2a and 2b.

Referring now more particularly to FIG. 1a of the drawings, there is represented in section an electrical connector of the multiple pin type having a body shell 11, an insulating support 12 of, for example, phenolic or epoxy-glass, and electrical contact members or pins 13. The pins 13 have end portions 15 adapted for the connection of electrical leads 16 thereto. At least the contact surface of each pin 13 comprises an alloy of at least one member selected from the group consisting essentially of indium, gallium, indium alloys and gallium alloys. Each pin 13 preferably is of a body material having a contact surface coating comprising an alloy of the body material with a member selected from the group consisting of indium, gallium, indium alloys and gallium alloys. The pins 13 preferably are of a non-ferrous metal or a non-ferrous alloy, for example, copper or beryllium-copper, zinc, aluminum, tin, or brass. Also suitable for the body materials of the pins 13 are antimony, bismuth, cadmium, gold, lead, magnesium, manganese, molybdenum, palladium, platinum, silver, titanium and zirconium. Alloys having major proportions by weight of any one or a plurality of the foregoing materials above-identified as being preferred or suitable for the body materials of the pins 13 may also be used for the body materials of the pins 13. Copper-nickel alloy having a major proportion by weight of copper is suitable for the body material of the pins 13.

Indium will diffuse into numerous other materials which may also be employed as body materials for the pins 13, but the rate of diffusion ordinarily is slower.

During manufacture the pins are coated with at least one member selected from the group consisting essentially of indium, gallium, indium alloys and gallium alloys. The pins preferably are electroplated to a thickness of 25×10^{-6} inch with indium, which has a melting point of 312° F. Suitable indium and gallium alloys are, for example, tin-indium, aluminum-indium, and zinc-indium alloys having an indium content of at least 50% by weight and tin-gallium, aluminum-gallium and zinc-gallium alloys having a gallium content of at least 50% by weight. Obviously, a plurality of the materials, for example, tin, aluminum and zinc, suitable for alloying with indium or gallium may form the minor proportion of the indium alloy or the minor proportion of the gallium alloy.

The pins are disposed at a temperature sufficient to cause substantially complete diffusion between the body material of the pins and the coatings. The body material of the pins preferably is a beryllium-copper alloy containing 1.28% beryllium. The pins preferably are indium-coated by electroplating or hot-dipping in indium and subsequently the indium preferably is diffused into the body material at a representative temperature cycle as follows: one-half hour at 350° F., one hour at 400° F., two hours at 600° F.

When the pins are heated to a temperature above

312° F., the indium melts and diffuses into the copper alloy pins. After the pins have been maintained at a temperature above the melting point of indium for a relatively short period of, for example, 30 minutes, the diffusion process can, if desired, be continued at room temperature, but at a much slower pace. After the diffusion process is completed, the pins have a contact surface coating comprising an alloy of the body material with indium and the free indium is substantially completely consumed. The surface is a copper-indium alloy having a melting point of approximately 900° C. The pins preferably are indium-coated and heated prior to mounting in the insulating support, but in some connectors it is also possible to coat and heat the pins after mounting in the insulating support.

A mating connector 17 (FIG. 1b) including an outer shell 18, an insulating support 19 and receptacles 20 preferably is manufactured in a manner similar to the connector 10. At least the contact surface of each receptacle 20 comprises an alloy of at least one member selected from the group consisting essentially of indium, gallium, indium alloys and gallium alloys. The receptacles 20 preferably have a contact surface coating comprising an alloy of body material with at least one member selected from the group consisting essentially of indium, gallium, indium alloys and gallium alloys. The same materials and method of manufacture described with reference to the FIG. 1a connector are suitable for the body and the surface coating of the FIG. 1b connector receptacles 20.

Referring now for the moment to FIGS. 2a and 3a, there is represented a finger-type electrical connector suitable for use in interconnecting printed circuits. Preferably a copper finger 22 extends to the edge of an insulating support 23 and is gripped by copper alloy spring members 24 (FIGS. 2b and 3b). The spring members 24 are integral with a copper conductor 25 mounted on an insulating support 26. At least the contact edge surface of the finger 22 has a surface coating consisting of an alloy of copper with at least one member selected from the group consisting essentially of indium, gallium, indium alloys and gallium alloys. The bodies and surface coatings of the finger 22 and spring members 24 may be of the same materials and manufactured in a manner similar to that previously described for the bodies and coatings of the pins and receptacles of the FIGS. 1a and 1b connectors.

From the foregoing description, it will be apparent that an electrical connector constructed in accordance with the invention has several advantages. The preferred temperature cycle yields a complete diffusion of indium into the body metal converting the .07 electron-volt potential of indium to copper entirely to a bonding energy, thereby forming a stable corrosion-resistant alloy. Since all the energy is dissipated as bonding energy, no potential is available for local cell activity. The indium reduces the coefficient of friction of the sliding surfaces and has the effect of hardening the outer surface. The copper-indium alloy provides an extremely corrosion-resistant, hard, non-tarnishing, low surface resistance connector member.

Moreover, a very thin oxide film forms on indium or indium alloys in the presence of oxygen or air. The conduction of electrons takes place through films of such thickness as, for example, 7 Angstrom units by the quantum mechanical tunnel effect.

The extremely rapid oxide film formation and the hardness of the base metal is believed to be the reason for the good wear characteristics of the connector.

Further, since indium diffuses into the body metal and eliminates the local cell activity, the connector is capable of being stored for indefinitely long periods of time.

I have found that connector pins coated with a copper-indium alloy as described above can be reinserted in a receptacle over 1200 times without deleterious effect on the resistance of the contact and without visible pin wear.

While there have been described what are at present considered to be the preferred embodiments of this invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention and it is, therefore, aimed to cover all such changes and modifications as fall within the true spirit and scope of the invention.

Having thus described my invention, what I claim and desire to protect by Letters Patent is:

1. A detachable alloy-surfaced electrical connector having a body material and a surface alloy and adapted for use with a similar surfaced mating connector over a long period of time, the detachable connector being alloy-surfaced to minimize corrosion of the type caused by local cell activity between metals of different potential in the electromotive series and being alloy-surfaced to minimize oxide film thickness on said surface alloy to maintain the conductivity of the connectors through their mating contact region, said surface alloy under such oxide film being an alloy of said body material with at least one member selected from the group consisting essentially of indium, gallium, indium alloys and gallium alloys, said selected member being substantially completely diffused into said body material to form said surface alloy.

2. A detachable alloy-surfaced electrical connector in accordance with claim 1 in which said selected member is an indium alloy having a major proportion by weight of indium.

3. A detachable alloy-surfaced electrical connector in accordance with claim 1 in which said selected member is indium.

4. A detachable alloy-surfaced electrical connector in accordance with claim 1 in which said surface alloy is a non-ferrous alloy.

5. A detachable alloy-surfaced electrical connector in accordance with claim 1 in which said surface alloy contains copper.

6. A detachable alloy-surfaced electrical connector in accordance with claim 1 in which said body material contains copper and in which said selected member is indium and in which said surface alloy is a copper-indium alloy.

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