

[54] **ZERO-INSERTION FORCE CONNECTOR**

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[22] Filed: **Dec. 6, 1971**

[21] Appl. No.: **205,181**

[52] U.S. Cl.....**339/74 R, 339/75 R, 339/278 C**

[51] Int. Cl.....**H01r 13/54, H01r 13/62**

[58] Field of Search.....**339/74, 75, 278**

[56] **References Cited**

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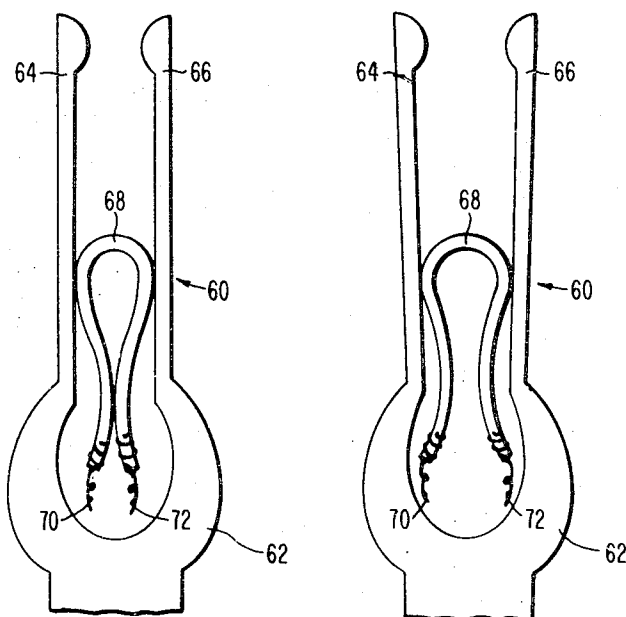
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[57] **ABSTRACT**

A zero-insertion force connector comprising a supply means for providing a thermal source and a base means adapted to support one or more pairs of mating contacts. A reversible motion actuator means comprising a temperature responsive nickel-titanium alloy is adapted for connection to the mating contacts. The actuator means is selectively responsive to the thermal source for opening the mating contacts for providing zero-insertion force for an electrical interconnection package having one or more pairs of electrical contacts thereon.

9 Claims, 4 Drawing Figures



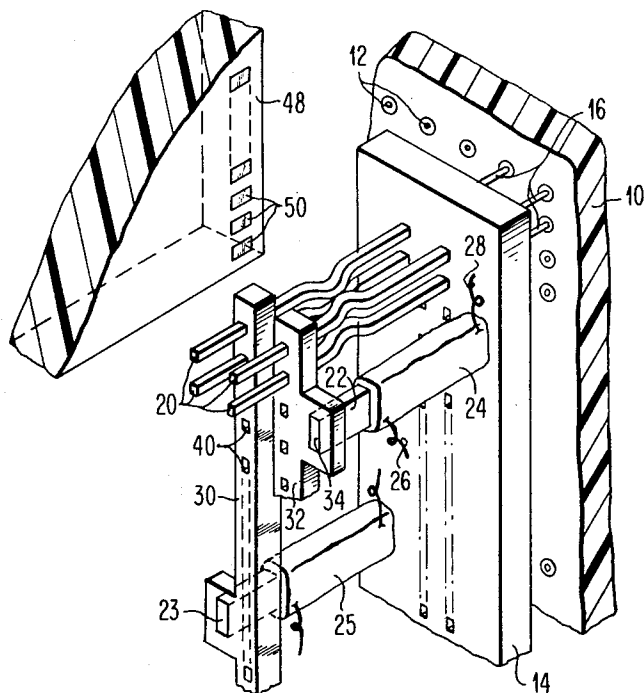


FIG. 1

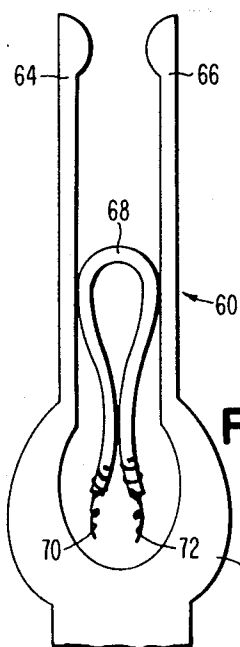


FIG. 2

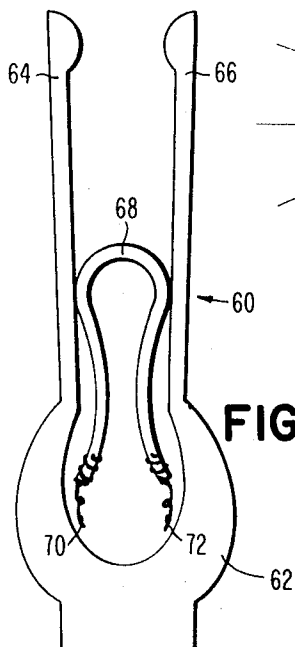


FIG. 3

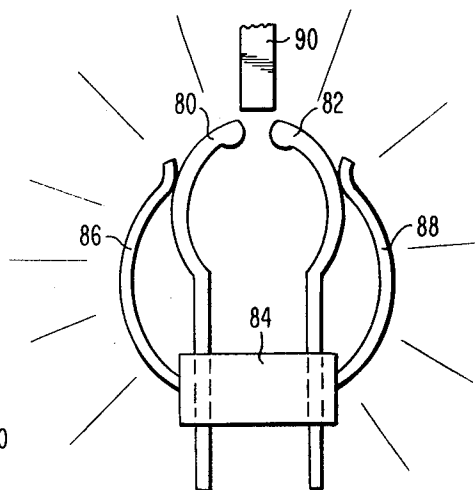


FIG. 4

ZERO-INSERTION FORCE CONNECTOR

BACKGROUND OF THE INVENTION

Brief Description of the Prior Art

High density connector systems often require zero-insertion force in order to prevent damage to one or both of the mating elements, and in addition, require critical wipe tolerances to be met. Zero-insertion force connectors have been previously designed based on mechanical action, such as cam or louver; air pressure; and thermal activation, such as solder reflow or bimetal systems. However, these prior art zero-insertion force connectors often require complex and costly mechanical arrangements, and thermal activating units unsuitable for miniaturization. Also, many of the prior art connectors require high power and will not operate at low temperatures, again, necessary for micro-miniaturization.

SUMMARY OF THE INVENTION

Therefore, it is an object of the present invention to provide a high density zero-insertion force connector which requires a minimal number of mechanical elements, and which is extremely suitable for micro-miniaturization because of its small size, low power and low temperature requirements.

In accordance with the aforementioned objects, the present invention provides a zero-insertion force connector comprising a base means for supporting a plurality of opposed matching contacts. A reversible motion actuator comprising a nickel-titanium temperature responsive alloy is adapted for connection to the plurality of matching opposed contacts and is selectively responsive to a source of heat for opening the matching opposed contacts in order to allow zero-insertion force of an electrical interconnection package therewith.

The foregoing and other objects, features and advantages of the invention will be apparent from the following more particular description of the preferred embodiment of the invention as illustrated in the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a partial, broken-away, perspective illustrating a preferred zero-insertion force connector embodiment.

FIGS. 2 through 4, inclusive, illustrate alternative structural versions for connecting the opposed matching contacts to a temperature responsive actuator comprising a titanium-nickel alloy.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Nickel-titanium alloys in the range of 53-57 percent nickel possess unique properties. A set shape is "memorized" by the material when it is formed and heated to approximately 1,000° F. Thereafter, it may be deformed in practically any manner, up to strains of about 10 percent. Once the material or part is heated to a particular transition temperature, it reverts towards or closely to its "memorized" shape, accompanied by the exertion of large mechanical forces. It is believed that the recovery to the "memorized" shape is due to a martensitic-type transformation.

In addition to its memory property, this material exhibits a quasi-discrete change in properties at its transition temperature. Below its transition temperature, the material is quite soft and deformable, for example, a Young's Modulus of about 4×10^6 psi, and a yield strength of approximately 12,000 psi. Above the transition temperature, the material becomes much more rigid, for example, a Young's Modulus of about 12×10^6 psi, and a yield strength of approximately 90,000 psi. The transition temperature can be varied as a function of the nickel-titanium composition.

A particular nickel-titanium composition of approximately 55 percent nickel by weight is nominally the equiatomic stoichiometric compound of nickel and titanium. Varying the nickel concentration between 53 and 57 percent will alter the transition temperature while still retaining the memory property. The range of transition temperatures, between -10° C to above 100° C can be further extended in the low temperature direction by partial substitution of nickel by cobalt.

FIG. 1 illustrates a zero-insertion force connector employing a nickel-titanium alloy having the above-described properties. A base member 10 is adapted to receive a plurality of pins at a plurality of electrical conductive openings 12. Another substrate 14, formed of a suitable insulative material, supports a plurality of pins 16 integrally formed therein and adaptable for mating with the openings 12.

A plurality of pairs of matching spring contacts designated at 20 are integrally and fixedly mounted into the upper surface of the insulative substrate 14 in order to electrically contact their respective pins 16 located on the under side of the substrate 14.

A plurality of nickel-titanium reversible motion actuator means are also rigidly mounted on the upper surface of the insulative substrate 14. The actuator means, only two of which are shown for purposes of simplicity, comprise a suitably formed nickel-titanium actuator bar 22 and 23. A source of heat is supplied to each individual actuator bar 22 by means of an electrical heating coil 24 and 25 surrounding the actuator bar 22 and 23, respectively. Electrical energy is supplied to the heating coil in a conventional manner, e.g. at a pair of terminals 26 and 28. A pair of insulator connector means 30 and 32 are employed to connect the actuator bar 26 to the pairs of spring contacts 20. An opening such as 34 is formed in the actuator connecting means 32 in order to slidably engage the actuator bar 22. Similarly, a plurality of passages 40 slidably engage the ends of the matching contacts 20 so as to complete the mechanical connection between the actuator elements and the spring contacts.

In order to insert an electrical interconnection substrate 48 having a plurality of electrical contacts 50 thereon, electrical energy is supplied to the heating coils 24 and 25 in order to heat the plurality of actuator bars 22 and 23 above their transition temperature. This force is transmitted via the connecting members 30 and 32 in order to move the pairs of matching contact springs to an open position so as to allow zero-insertion force of the substrate 48. In the embodiment of FIG. 1, the nickel-titanium actuator bars 22 revert to the "memorized" shape upon heating above its transition temperature. As the source of heat is removed and the material is cooled below its transition temperature, the

metal becomes soft and deformable, that is, it possesses a much lower Young's Modulus and yield strength properties. Below the transition temperature, the force exerted by the actuator bars 22 and 23 are insufficient to overcome the natural compressive force of the mating matching contacts 20 and thus, they return to a closed position. In other words, below the transition temperature, the force exerted by the plurality of pairs of metal contact springs 20, selected and formed of a spring metal normally in a compressive state, is greater and overcomes the force exerted by plurality of actuator bars 22 and 23.

FIG. 2 illustrates another embodiment comprising a tuning fork contact assembly 60 including a lower horseshoe portion 62 extending outwardly to a pair of matching spring contact arms 64 and 66. In this embodiment, the nickel-titanium reversible motion actuator comprising a temperature responsive nickel-titanium alloy comprises a horseshoe loop element 68. The electrical heating elements for raising the actuator element 68 above its transition temperature is schematically depicted by the contact leads 70 and 72.

In the embodiment of FIG. 2, the actuator element 68 is formed from commercially available nickel-titanium strips. In order to form the loop 68, strips of the material are shaped in a die to the desired memory shape, and annealed at 935° F for 30 minutes and then water quenched. The tuning fork contact element 62 is formed from a rectangular beryllium copper stock. In this embodiment, the pair of contact arms 64 and 66 are normally in a state of compression while the actuator element 68 is in a soft or ductile state below the transition temperature. In order to open the contact arms 64 and 66 for zero-insertion force of an electrical interconnection substrate (not shown) the actuator 68 is raised above its transition temperature by the application of a source of electricity to the terminals 70 and 72. This open position is illustrated in FIG. 3. In this state, the actuator element 68 is above its transition temperature and therefore, in its memory or high strength state.

FIG. 4 illustrates another embodiment wherein the composition of the nickel alloy is changed. Again, a pair of curved contact arms 80 and 82 are supported by an insulating block 84. In this instance, the actuator elements comprise a pair of semicircular arms 86 and 88 suitably mounted for support within the base means 84. An electrical interconnection substrate is shown at 90.

In this embodiment, the arms 80 and 82 are fabricated from conventional spring metal but are constructed such that they are in an open position without the restraining force supplied by the nickel-titanium alloy actuator arms 86 and 88. Thus, by appropriate selection of the nickel-titanium composition, the actuator arms 86 and 88 are in a high strength or memory state during ambient conditions, in order to maintain the contact arms 80 and 82 in a closed position.

In order to open the contact arms 80 and 82, a cooling source is directed at the actuator arms 86 and 88, such as a blast of cold air having a temperature below that of the ambient atmosphere. At a temperature below its transition temperature, the arms 86 and 88 revert to their low strength state and allow the contact arms 80 and 82 to open in order to accommodate the

insertion of the interconnection substrate 90 carrying contacts (not shown). This differs from the previous embodiments in that the memory or high strength state of the actuator arms 86 and 88 is employed to maintain the contacts 80 and 82 in a closed position. In other words, when the connector assembly is accommodating the electrical substrate 90, the ambient atmosphere provides a temperature which is above the transition temperature of the actuator elements 86 and 88.

The described embodiments provide a zero-insertion force connector which is extremely reliable as to the repeatability of contact opening and closing over an extended duty-cycle lifetime. Additionally, it differs from the known or standard bi-metallic strip in that it affords an actuator element having much higher deflection capabilities which function in a distinct on-off mode. In contradistinction, bi-metallic strips possess lower deflection capabilities and these mechanical displacements are of a proportional nature and do not respond in the positive on-off manner as that of the present invention.

One mentioned primary advantage of the present invention resides in the highly reliable gap opening repeatability within those tolerances over a great number of cycles. It was found that for various configurations of the nickel-alloy actuator elements, it is sometimes necessary to exercise the nickel-alloy actuator elements in order to stabilize the gap opening repeatability. That is, after the die molding and the water quenching steps set the nickel-alloy material to its desired memory state, a number of opening and closing or exercising steps are required in order to stabilize the contact gap repeatability.

While the invention has been particularly shown and described with reference to the preferred embodiments thereof, it will be understood by those skilled in the art that the foregoing and other changes in form and details may be made therein without departing from the spirit and scope of the invention.

What is claimed is:

1. A zero-insertion force connector comprising:
 - a. a supply means for providing a thermal source of energy,
 - b. a base means and at least one pair of mating contacts adapted to be supported by said base means,
 - c. a reversible motion actuator means comprising a temperature responsive nickel-titanium alloy adapted for connection to said at least one pair of mating contacts,
 - d. the actuator means being selectively responsive to the thermal source for opening said at least one pair of mating contacts for providing zero-insertion force for an electrical interconnection package.
2. A zero-insertion force connector as in claim 1 further including:
 - a. a plurality of pairs of mating contacts adapted to be supported by said base means.
3. A zero-insertion force connector as in claim 2 wherein:
 - a. said reversible motion actuator means comprises a first and a second state, said first state being constituted by a relatively high strength state and said second state being constituted by a relatively low strength state, and

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b. said reversible motion actuator means being responsive to said thermal source of energy for switching from said first state to said second state.

4. A zero-insertion force connector as in claim 3 wherein:

a. said plurality of pairs of mating contacts are normally in a state of compression, and

b. said reversible motion actuator means is responsive to said thermal source of energy for switching from said second state to said first state for opening said plurality of pairs of mating contacts for providing zero-insertion force for an electrical interconnection package having a plurality of electrical contacts thereon.

5. A zero-insertion force connector as in claim 4 wherein:

a. said supply means comprises a source of thermal heat for heating said reversible motion actuator means above its transition temperature for switching from its second state to its first state.

6. A zero-insertion force connector as in claim 4 wherein:

a. said plurality of pairs of mating contacts are normally biased open in the absence of external forces,

b. said reversible motion actuator means comprises a temperature responsive nickel-titanium alloy

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material which is in a first state under ambient conditions, and

c. said reversible motion actuator means is responsive to said thermal source of energy for switching from said first state to said second state so as to allow said plurality of pairs of mating contacts to be biased to their normally open state.

7. A zero-insertion force connector as in claim 6 wherein:

a. said supply means for providing a thermal source of energy comprises a cooling means for cooling said reversible motion actuator means below its transition temperature for switching from said first state to said second state.

8. A zero-insertion force connector as in claim 4 further including:

a. an insulating connector member adapted for engagement with said plurality of pairs of mating contacts and with said reversible motion actuator means.

9. A zero-insertion force connector as in claim 6 wherein:

a. said reversible motion actuator means is integrally connected with said plurality of pairs of mating contacts.

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