

[54] ELECTRICAL CONTACT AND METHOD OF FABRICATION

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[52] U.S. Cl. .... **29/630 C, 29/630 R, 72/47**

[51] Int. Cl. .... **H01r 9/00**

[58] Field of Search ..... 29/624, 626, 630 C, 630 F, 29/630 G, 470.1, 480, 484, 527.1, 527.2, 527.4; 72/47

[57] **ABSTRACT**

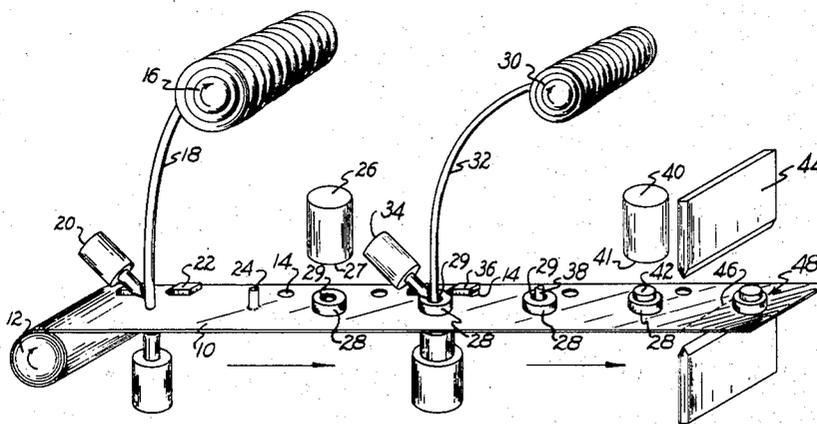
An improved electrical contact is disclosed including a heat sink layer secured to a substrate and an electrical contact layer secured to a surface of the heat sink layer. The heat sink layer and the contact layer are each of a generally nonuniform cross-section, including respective central portions of differing thicknesses with respect to the peripheries thereof disposed in mating relationship, with the contact layer terminating spaced inwardly from the periphery of the heat sink layer. In fabrication of the electrical contact the heat sink layer is deposited on the substrate and deformed to include a central portion of decreased thickness, while the contact layer is secured to the surface of the heat sink layer and similarly deformed to include a central portion of an increased thickness in mating relationship with the central portion of the heat sink layer and terminating spaced inwardly from the periphery of the heat sink layer.

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**7 Claims, 7 Drawing Figures**



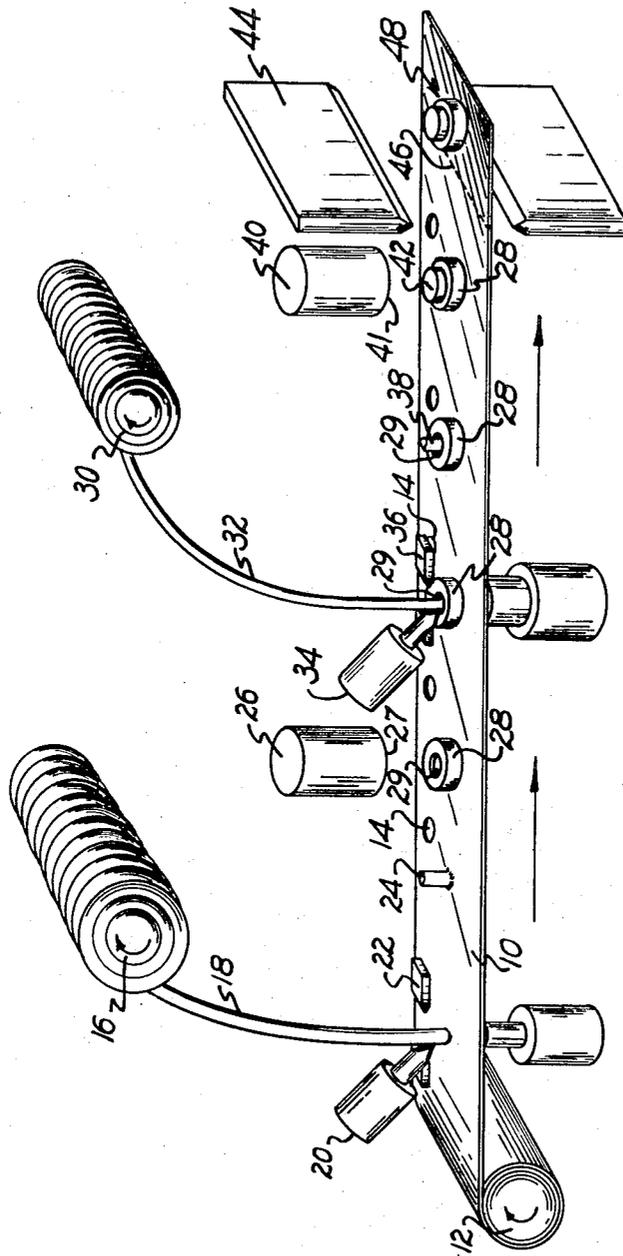


Fig. 1.

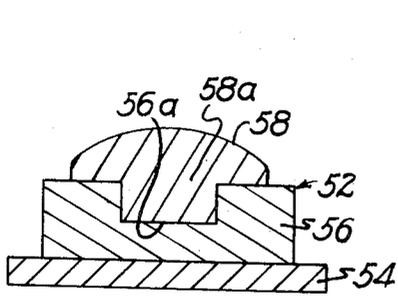


Fig. 2.

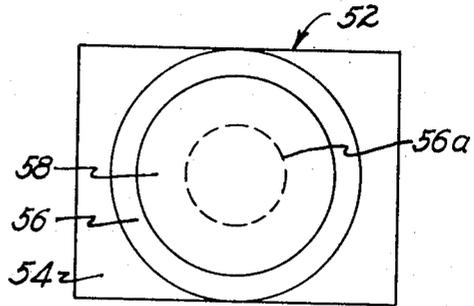


Fig. 3.

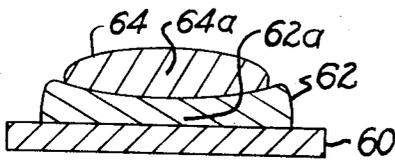


Fig. 4.

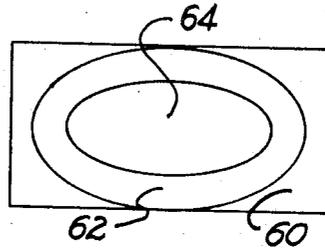


Fig. 5.

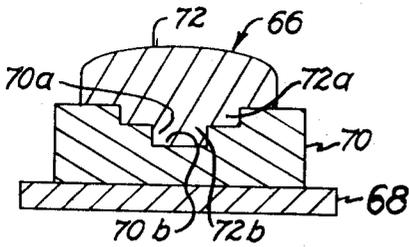


Fig. 6.

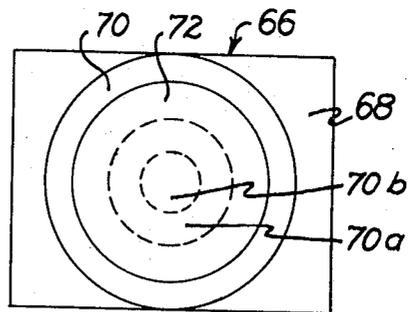


Fig. 7.

## ELECTRICAL CONTACT AND METHOD OF FABRICATION

This is a division, of application Ser. No. 112,534, filed Feb. 4, 1971, now U.S. Pat. No. 3,686,457.

The present invention relates generally to electrical contacts and more particularly is directed to improved multilayer electrical contacts including a heat sink layer and an electrical contact layer. Various types of electrical contact arrangements have been developed including numerous improvements, such as decreased contact resistance, increased electrical lifetime, etc. However, as technology has advanced resulting in decreased costs of various elements utilized in electrical systems as well as increased durability many electrical contact arrangements are still considered to have a relatively limited lifetime, particularly when exposed to continued repetitive operation in the presence of electrical arcing, and in certain instances remain quite expensive relative to the cost of other elements in such systems due to the usage of precious metals in the contact. More particularly, the current magnitude or amperage rating of the contact generally determines the surface area of the contact material, while the thickness of the contact arrangement generally governs the ultimate lifetime of the contact, since continued arcing eventually results in erosion of the contact material to a point at which the base metal or substrate is exposed resulting in eventual contact failure. Generally it is desirable to fabricate the exposed contact area of a relatively good electrical conductor which is resistant to corrosion and has a low contact resistance. Particularly suitable materials in this regard are silver, gold, and other precious metals which, of course, increase the cost of the contact. In order to reduce the cost of the contact, while providing suitable heat dissipation characteristics, in certain instances multi-layer contact arrangements have been suggested in which a heat sink such as a copper layer, is disposed intermediate the precious metal contact layer and the substrate or base metal. However, such contacts are still relatively expensive and are expendable in that burn-through of the contact layer eventually occurs, dictating the usage of increased quantities of expensive precious metal relative to the heat sink layer. Furthermore, ordinarily in fabricating such contacts the expense of fabrication is increased in view of the associated wastage of material during processing necessitating the implementation of scrap recovery procedures in order to recover all or part of the precious metal and/or copper scrap which is produced.

Accordingly, it is an object of the present invention to provide an improved method for fabricating an electrical contact device in which the usage of expensive materials is minimized and the cost of fabrication is reduced.

It is another object of the present invention to provide an improved method for fabricating an electrical contact device in which substantially all of the material being processed is utilized to eliminate the necessity for scrap recovery operations.

It is another object of the present invention to provide an improved electrical contact device in which the usage of relatively expensive material is minimized, while electrical lifetime is maintained at a relatively high level.

It is another object of the present invention to provide an improved electrical contact device which is extremely economical to fabricate and durable in use.

Various additional objects and advantages of the present invention will become readily apparent from the following detailed description and accompanying drawings wherein:

FIG. 1 is a perspective generally diagrammatic view of a preferred method for fabricating an electrical contact device in accordance with the principles of the present invention;

FIG. 2 is a vertical sectional view of one embodiment of an electrical contact device in accordance with the present invention;

FIG. 3 is a plan view of the device illustrated in FIG. 2;

FIG. 4 is a vertical sectional view of another embodiment of an electrical contact device in accordance with the present invention;

FIG. 5 is a plan view of the device illustrated in FIG. 4;

FIG. 6 is a vertical sectional view of still another embodiment of an electrical contact device in accordance with the present invention; and

FIG. 7 is a plan view of the device illustrated in FIG. 6.

Referring generally to the drawings and initially to FIG. 1 wherein a method of fabricating an electrical contact device in accordance with the principles of the present invention is illustrated, a continuous sheet of substrate or support material 10 is carried on a roll 12 and advanced in the direction indicated. As shown, the sheet of substrate material 10 may have a plurality of spaced pilot or index apertures 14 to aid in suitably positioning the material for subsequent processing operations. A suitably supported roll 16 carrying a coil of a first preselected metallic material 18 is provided adjacent the sheet 10 and, as shown, is adapted to feed the material 18 toward the surface of the sheet 10 where a first securing means 20, such as a suitable welding apparatus, is provided adjacent the sheet 10 to secure the leading edge of the material 18 to the sheet. In addition, a suitably supported cutter means 22 is arranged in alignment with the material 18 for effecting a separation or cutting operation immediately subsequent to the securing operation to effect the formation of segments of the material 18, defining first bodies 24 of heat sink material, which are, thus, successively deposited at spaced intervals on the surface of the substrate sheet 10 as it is continuously advanced. Subsequent to securing and separation the body 24 of heat sink material is carried by the advancing substrate 10 to a position in alignment with a first coining means 26 having a suitably shaped die face 27 adapted to deform substantially the entire body 24 of heat sink material into a preselected configuration to define a heat sink layer 28 having a generally nonuniform cross section including a central portion 29 of decreased thickness with respect to the periphery thereof. Another suitably supported roll 30 which carries a coil of a second preselected metallic material 32 is disposed adjacent the output edge of the first coining means 26 and, as shown, is adapted to feed the material 32 onto the exposed surfaces of the respective advancing heat sink layers 28. As the material 32 is fed onto the heat sink layers, a second securing means 34 such as a suitable welding apparatus, is provided for securing the leading edge of

the material 32 to the surface of the heat sink layer 28. In addition, a suitably supported cutter means 36 is positioned in alignment with the material 32 for effecting a cutting or separation operation immediately subsequent to the securement operation to provide individual segments of a predetermined length of the material 32, defining second bodies 38 of contact material which are, thus, successively secured to the exposed surfaces of the respective heat sink layers 28 as the sheet 10 is continuously advanced. The advancing sheet 10 then carries the heat sink layer 28 and the second body 38 to a position in alignment with a second coining device 40 having a suitably shaped die face 41 adapted to deform substantially the entire second body 38 into a preselected configuration defining an exposed contact layer 42 having a generally nonuniform cross-section including a central portion of an increased thickness with respect to the periphery thereof and in mating relationship with the central portion 29 of the heat sink layer 28, while terminating spaced inwardly from the periphery of the heat sink layer, as shown. A suitable separating device 44 is provided adjacent the output end of the coining device 40 and is adapted to effect a cut through the sheet 10 along the cut line 46 indicated so as to separate the sheet 10 carrying the spaced respective heat sink and contact layers into individual portions to define completed units 48.

The substrate material 10 carried on the roll 12 preferably comprises a relatively thin sheet of a suitable metallic material. In this regard the sheet 10 is selected with regard to properties desirable in accordance with the ultimate environment and application of the contact 48. For example, if increased structural strength is desired thin coiled sheets of various types of low carbon steels may be suitable such as that commonly identified as SAE (Society of Automotive Engineers) No. 1010 low carbon steel which comprises by weight approximately between 0.08 to 0.13 percent carbon, 0.30 to 0.60 percent manganese, 0.040 percent (max.) phosphorous, 0.050 percent (max.) sulphur and the balance iron. Similarly, in certain other instances suitable thin coiled sheets of brass or bronze may be utilized, while in other instances thin coiled sheets of phosphor bronze, various monel metals, etc. may be utilized. In the illustrated embodiment the sheet is utilized primarily as a carrier for the heat sink and contact layers and is relatively thin, varying in thickness between approximately 0.008 to 0.070 inch, although other thicknesses may be appropriate in certain instances.

The roll 16 of material 18 preferably comprises a suitably supported roll of a coiled rod-like member or wire of material having a high thermal conductivity, such as substantially pure copper wire. Copper wire is particularly advantageous in this regard in view of its ready availability, low cost, and ease of processing, in this form. The copper wire 18 preferably has a circular cross-section for reasons of economy although other cross-sectional configurations may be utilized if desired. The copper wire 18 has a preselected diameter such that the bodies 24 formed therefrom are of a sufficient size to permit formation of the heat sink layer 28 in the desired configuration. In the illustrated embodiment the copper wire 18 may have a diameter of between approximately 0.062 to 0.250 inch, although, if desired, other sized wire may be utilized. The welding

means 20 may comprise any one of a variety of conventional welding apparatus, although in view of the difficulty in welding copper due to its high thermal conductivity it is generally desirable to utilize a suitable point welding apparatus which is not shown in detail, since such apparatus is conventionally available. The first coining or deforming means 26 which is disposed adjacent the output edge of the welding means 20 is suitably supported and may be operated electrically, hydraulically or in other conventional ways, and is arranged to deform substantially the entire body 18 to form the heat sink layer 28 without any material loss, obviating the necessity for subsequent scrap recovery operations. In this connection the die face 27 may be shaped to deform the heat sink layer 22 to include the generally centrally located depression 29 for accommodating the thicker central portion of the contact layer 42 in mating relationship therewith. Although in the illustrated embodiment the heat sink layer 28 is shown in a generally circular configuration, other configurations may be readily formed such as rectangular shaped bodies, elliptically-shaped bodies, etc. an important feature being the inclusion of a generally centrally located depression of reduced thickness with regard to the periphery thereof so as to form a layer having a nonuniform cross-section to accommodate an increased thickness of contact layer material at the central region thereof. In the illustrated embodiment the heat sink layer 28 may be deformed to a thickness of between approximately 0.010 to 0.125 inch, while the depression 29 may be formed to extend smoothly from the periphery progressively decreasing in thickness or may be formed as an abrupt slot at the center of the layer. Similarly the depression 29 may extend inwardly from the exposed surface of the layer 28 a predetermined distance depending upon the ultimate application intended for the contact system, although preferably the depression region retains approximately half the thickness of the layer 28 in order to avoid adversely affecting the heat sink properties of the heat sink layer 28.

As the heat sink layer 28 is advanced in the direction indicated toward the succeeding station at which the roll 30 is positioned the contact body 38 is secured to the surface of the heat sink layer 28 generally in alignment with the centrally located depression 29. The contact body 38 preferably comprises a preselected metallic material having a relatively high electrical conductivity and low contact resistance, as well as good corrosion resistance properties. Preferably the contact body comprises a material, such as silver, silver cadmium oxide, gold, palladium, platinum or alloys thereof. The contact body material 32 is preferably initially provided in the form of a coiled generally rod-like member, such as a circular wire coiled on the roll 30, as previously explained in connection with the material 18, but may be provided in other configurations, if desired. In the illustrated embodiment the material 32 may have a diameter of between approximately 0.020 to 0.187 inch depending upon the relative size of the underlying copper heat sink layer 28 and the ultimate properties desired for the completed contact unit 48, but is reduced in thickness by approximately 50 percent or less by the second coining means 40 except for the thicker central region defined in the subsequently formed contact layer 42. The second securing means 38 may again comprise a suitable point welding appara-

tus adapted to rigidly attach the contact body 38 to the heat sink layer 28. After separation of the segment defining the contact body 38 from the coil 30 subsequent to the welding operation the heat sink layer 28 with the contact body 38 secured to its surface is advanced to a position in registration with the die face 41 of the second coining means 40, as shown, which deforms substantially the entire contact body 38 into the configuration defining the contact layer 42 without producing any excess material, thereby obviating the necessity for any scrap recovery operation. The space defined by the depression 29 in the heat sink layer 28 is occupied by the thicker central portion of the contact layer. Furthermore, the contact layer 42 is deformed to extend over a predetermined area of the exposed surface of the heat sink layer 28, but terminates at a location spaced inwardly from the peripheral boundary of the heat sink layer 28. The deformed contact layer 42, thus defines a configuration in which the central region is of an increased thickness with regard to the peripheral portions thereof, while its peripheral boundary is spaced inwardly from the periphery of the heat sink layer 28. In a preferred embodiment the contact layer 42 may occupy between approximately 50 to 90 percent of the exposed surface area of the heat sink layer, thereby reducing the usage of the relatively expensive contact layer material while providing increased quantities of contact material at the critical central region of the contact unit 48 where such material is needed. As may be seen the sheet 10 including the heat sink layer 28 and the contact layer 42 is then advanced to a position in registration with the separating means 44 which effects a cut along the separation line 46 to provide the composite completed contact unit 48. Although in the preceding description and accompany drawing the segments of heat sink material and contact layer material are secured to the substrate sheet at their respective exposed end edges and hence are in a vertical orientation prior to deformation, it should be noted that in certain instances the segments may be disposed on the advancing substrate sheet in a horizontal orientation with a portion of the outer surface of the segment being secured in position prior to deformation.

Various embodiments of contact units such as the unit 48 are illustrated and described in detail hereinafter indicative of typical examples of contact units in accordance with the present invention which may be fabricated utilizing a method such as that described in detail in connection with FIG. 1 by varying the shape of the die faces 27, 41 of the deforming means 26, 40 respectively.

Referring now in detail initially to FIGS. 2 and 3 which respectively illustrate a vertical sectional view and a plan view of one embodiment of a contact unit, indicated generally by the reference numeral 52, in accordance with the present invention it may be seen that the contact unit 52 includes a substrate 54 preferably fabricated of a preselected metallic material, such as the material comprising the sheet 10 described in connection with FIG. 1. A heat sink layer 56 of a first preselected metallic material having a relatively high electrical and thermal conductivity is disposed on one surface of the substrate 54, while a contact layer 58 of a second preselected metallic material having a relatively high electrical conductivity is disposed on an exposed surface of the heat sink layer 56. The heat sink layer 56 and the contact layer 58 may be affixed in position and

deformed into the illustrated configuration generally in accordance with the method as described hereinabove in connection with FIG. 1. More particularly, the substrate 54 may comprise a suitable low carbon steel, such as described in connection with FIG. 1, or other metallic material selected with a view to the contemplated usage of the contact unit 52. The substrate 54 may be generally coextensive with the overlying heat sink layer 56 or may be slightly larger, as shown in the illustrated embodiment, in order to facilitate disposition of the contact unit 52 in position in a desired application. The heat sink layer 56 is preferably fabricated of a material, such as copper, which is noted for its good electrical and thermal conductivity, and is arranged in a generally circular configuration, as particularly illustrated in FIG. 3, while having a nonuniform cross-sectional configuration or thickness, including a central region 56a of a reduced thickness with respect to the periphery thereof. As shown, the contact layer 58 is secured to the exposed surface of the heat sink layer 56 and preferably comprises a material having a relatively high electrical conductivity and low contact resistance, as well as good corrosion resistance properties, such as silver, gold, palladium, platinum or alloys thereof. In addition, in certain instances a material such as silver cadmium oxide may be utilized in fabricating the contact layer 58. The contact layer 58 similarly has a generally circular configuration as shown in FIG. 3 and is also arranged to have a generally nonuniform cross-section or thickness, including a central region 58a of an increased thickness with respect to the peripheral portions thereof. The portion 58a of increased thickness and the portion 56a of decreased thickness of the contact layer and heat sink layer respectively are disposed in mating relationship with respect to each other so as to define a structure in which an increased amount of contact layer material is provided only at the central portion of the contact system 52. In addition, as shown, the contact layer 58 is arranged such that it is noncoextensive with the heat sink layer 56 and terminates at a position spaced inwardly from the peripheral boundary of the heat sink layer. Thus, the total usage of the relatively more expensive contact layer material is minimized, while providing an increased amount at the central portion of the contact system. Such an arrangement has been found to provide significant benefits in prolonging the electrical lifetime of the unit, since it has been found that the central region is generally subjected to the greatest electrical stress, while the relatively larger area, less expensive heat sink layer 56 improves the heat dissipation properties of the unit 52 so as to permit fabrication of a unit which is less expensive but has improved electrical lifetime and current carrying characteristics. In this connection a substantial cost and performance advantages result from utilizing a system such as that illustrated in which more expensive contact material is provided only at the central region of the contact unit since such an arrangement minimizes the total usage of expensive contact layer material by effecting replacement of such material at less critical areas with less expensive heat sink material. In a preferred embodiment of a unit, such as that illustrated in FIGS. 2 and 3, in which the heat sink layer and contact layer have generally circular-shaped peripheral boundaries the contact layer 58 occupies between approximately 50 to 90 percent of the exposed surface area of the heat sink layer. Furthermore, it may be

noted that substantial economic savings accrue in view of the replacement of more expensive contact material with less expensive heat sink material since a circular geometric configuration is involved in which the area varies with the square of the diameter.

Although the embodiment illustrated in FIGS. 2 and 3 is shown having a central region in which the thickness of the heat sink layer is relatively abruptly reduced in a stepped configuration to accommodate a corresponding abrupt increase in the thickness of the contact layer, it may be desirable in certain instances to provide such a system in which a smooth progressive decrease in thickness in the heat sink layer is accomplished extending toward the center thereof, while the contact layer is arranged to similarly progressively increase in thickness extending toward the center thereof. Such an embodiment is illustrated in detail in FIGS. 4 and 5. More particularly, in this embodiment a substrate 60 similar to the substrate 54 is initially provided. A heat sink layer 62 is secured to a surface of the substrate 60, the heat sink layer including a generally centrally located region 62a of a reduced thickness with respect to the periphery thereof and a contact layer 64 is secured to the exposed surface of the heat sink layer 62, the contact layer having a generally centrally arranged portion 64a of an increased thickness with respect to the periphery thereof disposed in mating relationship with the reduced thickness portion 62a. The contact layer 64a is noncoextensive with the heat sink layer 62, terminating spaced inwardly from the peripheral boundary of the heat sink layer 62. The heat sink layer 62 again comprises a material having a relatively good thermal and electrical conductivity, such as copper, while the contact layer 64 again comprises a material having a relatively high electrical conductivity, low contact resistance, and good corrosion resistance properties such as silver, gold, palladium, platinum or alloys thereof or in certain instances silver cadmium oxide. In this embodiment as shown particularly in FIG. 5 the heat sink layer and contact layer are each formed in a generally elliptical configuration which has been found to be advantageous in certain instances. In addition, it may be seen that the heat sink layer 62 progressively decreases in thickness from the outer periphery thereof toward the center while the contact layer 64 progressively increases in thickness from the periphery thereof toward the center thereof so as to define a contact system in which an increased amount of contact material is provided only at the center thereof so as to increase the electrical lifetime, while minimizing the usage of relatively expensive contact material. In one example of a contact arrangement such as that illustrated in FIG. 4 it has been found that substantial advantages reside in arranging the relative thicknesses of the heat sink layer 62 and contact layer 64 such that there is a difference in relative thicknesses at the respective centers of each of these layers of between approximately 1 to 5 percent, while the outer peripheral edges of each of these respective layers are approximately equal in thickness with respect to each other. In addition, it has been found particularly advantageous in certain instances to arrange the relative surface dimensions of the heat sink layer and the contact layer such that the contact layer occupies between approximately 50 to 90 percent of the exposed surface area of the heat sink layer in order to provide a structure in which a substantial cost savings results

due to reduced usage of the relatively expensive contact layer material while achieving improved electrical lifetime characteristics and current carrying abilities as compared with conventional contact units, utilizing substantially greater quantities of more expensive contact material.

Referring now to FIGS. 6 and 7 another alternate embodiment of the present invention is illustrated comprising a contact unit indicated generally by the reference numeral 66 in which an increased volume of contact material is provided only at the central region thereof. More particularly, the illustrated embodiment includes a substrate 68 similar to the substrate 60 in the preceding embodiment, as well as a heat sink layer 70 secured to a surface of the substrate 60 and preferably fabricated of a material, such as copper having a high electrical and thermal conductivity, and an electrical contact layer 72 secured to a portion of the exposed surface of the heat sink layer 70, the contact layer 72 being fabricated of a material having a relatively high electrical conductivity and good corrosion resistance properties, such as silver, gold, palladium, platinum or alloys thereof or of a material such as silver cadmium oxide. In this embodiment, the heat sink layer 70 includes a central region having a plurality of stepped areas 70a and 70b which successively decrease in thickness toward the center of the heat sink layer. The areas 70a and 70b are defined by generally circular-shaped peripheral boundaries, as particularly indicated in FIG. 7 so as to define the heat sink layer 70 such that the thickness thereof decreases progressively towards the center to permit the heat sink layer to accommodate the overlying electrical contact layer 72 which is provided with complementary mating stepped regions 72a, 72b which successively increase in thickness approaching the center thereof. More particularly, it may be seen that the contact layer 72 similarly includes generally circularly bounded stepped areas 72a, 72b which increase progressively in thickness toward the center thereof and are arranged in mating relationship with the regions 70a, 70b of progressively decreasing thickness of the heat sink layer 70 so as to provide a central area having a still further increased amount of contact layer material at the center thereof while minimizing the actual usage of contact layer material at areas other than the center thereof, thereby providing a completed contact unit in which a maximum volume of contact layer material is replaced by less expensive heat sink material at areas other than the critical central region of the unit so as to provide a device having improved electrical capabilities in view of the increased provision of contact layer material at areas of greatest need while minimizing the overall usage of contact layer material.

It should be readily apparent that various other alternative shapes of contact arrangements may be readily provided utilizing the above-described principles in which a central region of a decreased thickness in the heat sink layer is provided with a corresponding complementary central region of an increased thickness of contact layer material being provided in mating relationship therewith so as to define a contact unit in which the usage of relatively expensive contact layer material is minimized, while providing a device having requisite electrical lifetime and current carrying capabilities.

Thus, a novel method has been described for fabricating an improved electrical contact unit in which the usage of relatively expensive contact layer material is minimized, while also eliminating the problem of scrap generation and necessity for recovery thereof. In addition, a number of contact units which may be fabricated in accordance with the principles of such a method have been described in detail.

Various changes and modifications in the above described embodiments will be readily apparent to those skilled in the art and any of such changes or modifications are deemed to be within the spirit and scope of the appended claims.

What is claimed is:

1. A method of fabricating an electrical contact device comprising welding a first body of a first metallic heat sink material having a relatively high thermal conductivity onto a metal substrate, deforming substantially the entire first body into a heat sink layer having a selected shape and a selected peripheral size, welding a second body of a second metallic material having a high electrical conductivity to a central portion of said previously formed heat sink layer, and deforming substantially the entire second body into an exposed contact layer of selected peripheral size and shape having the periphery of said contact layer spaced inwardly from the periphery of said heat sink layer.

2. A method in accordance with claim 1 wherein said first body comprises copper and said second body is selected from the group consisting of silver, silver cad-

mium oxide, gold, palladium, platinum and alloys thereof.

3. A method in accordance with claim 1 wherein said first and second bodies are respectively deformed to have generally circular bounded exposed surface portions.

4. A method in accordance with claim 1 wherein said first and second bodies are respectively deformed to have generally elliptically bounded exposed surface portions.

5. A method in accordance with claim 1 wherein the deformation of said first body to form the central portion of decreased thickness includes deforming the central portion to include stepped regions which progressively decrease in thickness toward the center thereof.

6. A method in accordance with claim 5 wherein said first and second bodies are respectively deformed to have generally circular bounded exposed surface portions and said stepped regions have generally circular-shaped boundaries.

7. A method in accordance with claim 1 wherein said first and second bodies comprise segments of first and second rod-like members having a generally circular cross-sectional configuration and the diameter of said second rod-like member is approximately between 50 to 90 percent of the diameter of said first rod-like member.

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