July 10, 1956 V. CLAIR, JR 2,754,393

ELECTRICAL CONTACT AND METHOD OF MAKING SAME

Filed Feb. 14, 1952

Fig. 1.

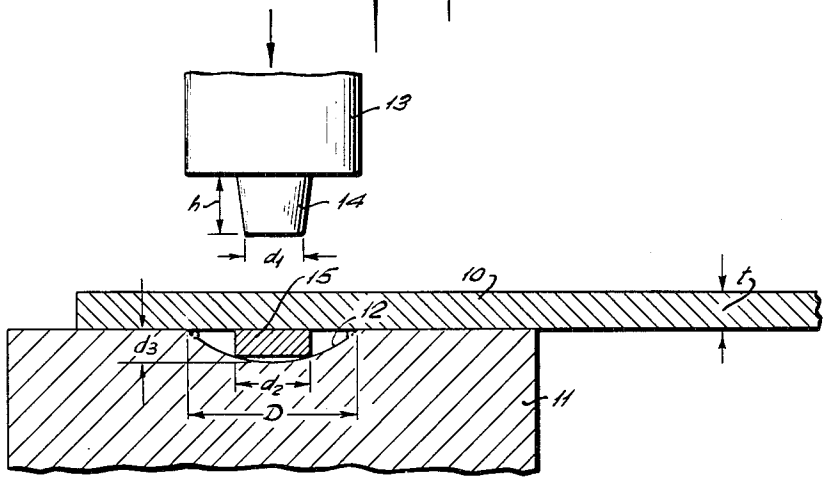


Fig. 2.

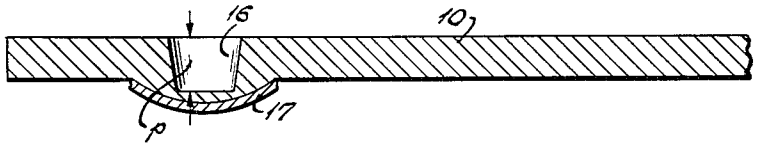
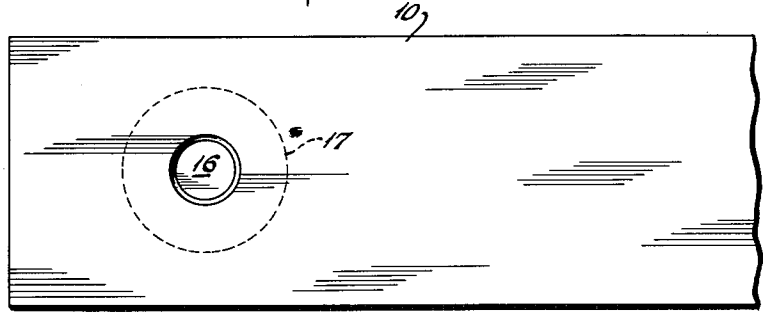


Fig. 3.



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ELECTRICAL CONTACT AND METHOD OF MAKING SAME

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The present invention relates to cold pressure welding, more particularly to the production of electrical contact members upon metallic supporting strips or bars, of copper, aluminum or other cold weldable metal or alloy, said member being provided or clad with a layer of a different current carrying and also cold weldable metal, such as silver or the like, firmly bonded thereto by cold welding.

Among the objects of the invention is the provision of an electrical contact member which may be manufactured efficiently and expeditiously by a simple pressure operation; which will have an increased current carrying capacity of the contact especially at the connection between the contact proper and the contact member or support; wherein the bond between the contact proper and the arm or support will be strong enough so that it cannot be destroyed under extreme arcing and as a result of sustained operating cycles; wherein the connection between the contact proper and the contact member is physically stronger than has been possible with connecting methods heretofore known; and which will require a minimum of contact material, such as silver, to reduce the manufacturing costs.

With these objects in view, the invention contemplates essentially the utilization of cold pressure welding for the production of a completely new electrical contact, wherein the contact element proper of an appropriate current carrying material, such as silver, is secured directly and intimately to the contact arm or support of an appropriate conducting material, such as copper, aluminum, or a suitable alloy, in the form of a thin layer by a cold welded joint, without requiring any foreign material, such as binders, fluxes, solder or other elements at the interface between the contact and contact arm or member.

The contact element or material proper is applied to the contact member or bar in the form of a small slug or pellet of silver or equivalent contact metal or metal alloy which becomes deformed or flattened during the pressure welding operation applied by the cold welding tools, in such a manner as to cold flow and merge with the metal of the adjoining surfaces of the bar and contact member. The pressure tools are so designed and the pressure upon the element and bar is so controlled or directed by the proper shape of the tools, as to produce or mold, as it were, both the contact member and to cause the contact material to spread over and become intimately welded to the element, to result in a final silver-coated contact or contact point capped by a layer of contact metal, in the manner described in detail hereinafter.

In this way, an article is produced which has a perfect current carrying engagement between the contact point or element and the contact arm, and no elements are present which will increase the transition resistance at the interface, while requiring a minimum of silver or equivalent contact material.

In addition, such a contact obviates a weakening or softening of the material which heretofore has often been

an inherent result of prior welding or pressing operations in the manufacture of electrical contacts of this type.

Furthermore, the utilization of cold pressure welding to interengage a contact layer or surface with a contact member and which also serves to form the shape of the contact member, results in a hardening or toughening of the metal of the contact member and the contact arm as a result of the concomitant strain or work hardening of the metal by the pressure as a result of the cold welding operation. This increases the structural strength of the contact and its ability to withstand the impact of successive tripping or closing operations.

As is well known, in electrical circuit breaker and other switch construction, when the circuit is closed the engagement between the contacts must be made rapidly or firmly. Consequently, great stresses are frequently set up in the contact arm, and where the contact arm and the member have been softened by ordinary welding or equivalent processes, the design must include some provision, such as increased cross-section or the use of reinforcing elements, to compensate for such weakening.

Also in the opening of electrical switches or circuit breakers, it is essential that any mechanical delay in the extinguishment of the arc be reduced to the absolute minimum and for this reason contact arms are biased by powerful springs which in turn exert an exceedingly great impact force on the arm when it reaches the stop near the open position.

Again, where contact members have been secured to contact arms by known welding or like processes, the weakening of the arm at the weld requires a greatly increased cross-section or other reinforcing means, in order to withstand the impacting operation.

Accordingly, a more specific object of the invention is the production of a novel electrical contact, wherein the contact element is secured directly to a contact member or support and wherein no alien substance is present at the interface.

Another object is the provision of a contact member and contact arm as above, whereby the hardness of the member and contact arm at least at or near the area of interconnection therebetween is increased.

The invention will be better understood by reference to the following detailed description considered in conjunction with the accompanying drawing, forming part of this specification, and wherein:

Figure 1 illustrates schematically a welding tool assembly, shown partly in cross-section, for producing cold-welded electrical contacts in accordance with the invention, the parts being shown in their position prior to welding; while

Figures 2 and 3 are vertical cross-section and plan views, respectively, of a cold-welded electrical contact obtained by means of the tool shown in Figure 1.

Like reference characters denote like parts in the several views of the drawing.

While the invention is specifically concerned with cold pressure welding an electrical contact, i. e. welding essentially by pressure and without the supply of any external heat, it will be understood that some heat may be used by either heating the welding tools or preheating the parts to be welded, provided, however, that welding is effected predominantly as a result of the plastic metal flow caused by the pressure applied to the parts by the tools.

Referring more particularly to Figure 1 of the drawing, the numeral 10 represents a contact bar or strip of aluminum, copper, brass, or other ductile and pressure weldable metal or metal alloy, upon which is to be formed a projection or contact point clad with a different current carrying metal also capable of pressure welding, such

as silver or other precious or inert metal. For this purpose, the bar **10** is laid upon a lower flat anvil or first welding tool **11** provided with a depression or mold **12** which conforms to the desired shape of the projection or contact to be formed, the cross-section of which may be a circular arc as shown.

The tool **11** cooperates with a further pressure tool or die **13** having a flat surface and projecting therefrom a slightly outwardly tapering welding tip **14** of circular cross-section, in the example shown, and being centrally aligned with the depression **12** in the tool or anvil **11**. Item **15** is a disc or slug of silver or equivalent contact metal placed in the depression **12** between the anvil **11** and the contact bar **10**.

In operation, upon bringing down the tool **13** upon the bar **10** with sufficient pressure supplied by a suitable press, which may structurally incorporate the tools **11** and **13**, the tip **14** in indenting the metal of the bar **10** will cause a flow of the metals of both the bar and the slug **15** laterally and in the direction of the applied pressure indicated by the arrow in the drawing. This plastic metal flow caused by the applied tool pressure, results in an extrusion of the metal of the bar **10** and spreading or stretching of the slug **15**, in such a manner as to effect a merging into an intimate and solid phase welding bond and to form or forge a contact upon the bar having a shape determined by the shape of the depression **12** and shown more clearly in Figure 2. In the latter, the indentation or depression made by the welding tool or tip **14** is shown at **16**, while **17** indicates the layer of silver or other contact metal which is firmly welded or bonded to the contact member proper produced by the tool pressure or plastic metal flow at and near the pressure or welding area.

The adjoining surfaces of the bar **10** and disc or pellet **15** are suitably cleaned, such as by subjecting them to scratch brush treatment, or by scraping with a suitable tool, to remove the surface oxide and other foreign matter and to provide clean metallic surfaces prior to welding. In many cases cleaning may, however, be dispensed with, in that the applied welding pressure will be sufficient to crack or destroy the thin oxide film to allow merging of the metals into a good weld connection or bond. This applies especially to silver or equivalent precious metals or metal alloys serving as contact material.

In order to effect a satisfactory metal flow conducive to good pressure welding, a minimum tool penetration p, Figure 2, must be effected being characteristic of the metal of the bar **10** and corresponding to about 80% total percentage reduction of the material for copper or about 60% total percentage reduction for aluminum, in accordance with the different degrees of cold weldability of the respective metals.

Since the thickness of the layer **17** is small compared with the thickness t of the bar **10**, it has practically no effect on the total percentage reduction or tool penetration, whereby the latter is substantially determined by the "Figure of Merit" of the material of the bar, i. e. about 80% for copper and 60% for aluminum. For other metals, the values may be determined from the table given in U. S. Patent 2,522,408, issued September 12, 1950.

It has also been found that an appropriate relationship should be maintained between the diameter d_1 of the tool or tip **14** and the mouth diameter D or opening of the mold or depression **12**, an average practical value for the ratio d_1:D to give satisfactory results being about 1:2, as shown in the drawing. The same applies to the width or diameter d_2 of the slug or pellet **15**, a practical average diameter for which has been found to be about one-half the opening or mouth width D of the depression **12** or diameter of the contact, the thickness of the slug also depending upon the desired final thickness of the metal layer **17**. In the example described, this thickness would be about four times the final thickness of the layer or element **17**, as will be understood. The depth p of the indentation **16** or penetration of the welding tool may be controlled in any suitable manner, such as by a mechanical stop associated with the press or by the height h of the tip **14** as shown in the drawing, in which case the lower flat surface of the tool member **13** acts as an abutment in limiting the tool penetration, as is understood.

The above dimensions, which may be varied within limits, apply especially to the forming of a contact point or projection having a height d_3 of the order of the gauge thickness t of the contact bar or strip **10** and a diameter D of the depression **12** or contact point being about $5t$, corresponding to a width or diameter d_1 of the weld indentation about $2.5t$, in accordance with the practical example given in the following.

While a round or dome-shaped contact has been shown in the drawing, it is understood that the shape of the depression **12** and the tool tip **14** may be of different configuration, although a circular or round contact shape insures a most favorable and uniform metal flow conducive to good cold welding and forging of a contact of desirable mechanical as well as electrical characteristics.

According to a practical example of a contact made in accordance with the method of the invention, a copper bar **10** was used having a thickness of 0.062" and the diameter D of the depression **12** in the tool **11** of mild steel was 0.300" and its maximum depth 0.64". The slug or pellet **15** of silver had a diameter of 0.150" and a thickness of 0.040". The average diameter of the tool tip **14** was 0.150" corresponding to the diameter of the slug **15** and the height h of the tool or depth p of the depression was 0.100", resulting in a final metal thickness at the center of the dome-shaped contact of 0.026". This gives a resultant percentage reduction of about 80% of the total thickness of the bar and contact, corresponding to the characteristic value for copper, and a thickness of the silver layer **17** of about 0.010". If an aluminum bar is used, the total minimum percentage reduction may be reduced to about 60% to obtain good welding as pointed out above.

Expressed in a different manner, the contact bar is depressed by the welding tool to an extent of about 1.6 times its thickness t in the case of copper, or about 1.2 times its thickness in the case of aluminum. This minimum depression or indentation insures a favorable cold or plastic flow of the metals under the applied pressure conducive to good cold welding of the contact metal and forging of the final shape of the contact.

It is possible, however, such as in the case of aluminum, to effect the same indentation as for copper, i. e. 80% of the total thickness of the bar and contact, to obtain the same metal displacement or size of the contact, the characteristic values given representing minimum values insuring good cold welding. An increase of the depth of the indentation beyond the minimum will result in a more intimate electrical contact connection, adequate mechanical strength of the contact being provided by the adjacent metal which has been hardened or toughtened as a result of pressure working.

On the other hand, if, in the example described, the depth of the indentation in case of aluminum is reduced to the minimum of about 60%, or 0.075", the resultant decrease in the amount of the displaced metal may be taken care of by decreasing the size of or space enclosed by the depression **12**, preferably by reducing its diameter D to provide a cylindrical edge or surface at the periphery of the final contact, shape as shown more clearly in Figure 2.

As pointed out above, the advantage of the invention over known methods of securing a contact element to a contact bar, such as by soldering, brazing, riveting or simple clamping, in addition to reducing the amount of silver or other contact material to a minimum, is the fact that the contact metal is hardened or toughened by the

work hardening effect occuring simultaneously with the forging and welding of the contact to the base metal. This not only provides a contact of improved mechanical strength capable of withstanding continuous wear and stress during use, but eliminates any special surface finishing or polishing, as the contact itself is formed or forged during the pressure application into its final shape determined by the depression in the anvil or lower welding tool.

In the foregoing the invention has been described with reference to a specific illustrative tool and method. It will be evident, however, that modifications and variations, as well as the substitution of equivalent parts and steps for those shown and described herein for illustration, may be made without departing from the broad scope and spirit of the invention as set forth in the appended claims. The specification and drawing are accordingly to be regarded in an illustrative rather than in a limiting sense.

I claim:

1. An electrical contact consisting of a contact member having a depression on one side and a hollow pressure-hardened integral contact projecting from said member opposite to said depression having a thickness equal to a substantial fraction of the thickness of said member, said contact being capped by a layer of different contact metal firmly bonded thereto by a solid phase cold weld joint.

2. An electrical contact consisting of a copper contact plate having a depression on one side and a hollow pressure-hardened integral contact projecting from said plate opposite to said depression having a thickness equal to about 20% of the thickness of said plate, said contact being capped by a layer of silver firmly bonded thereto by a solid phase cold weld joint.

3. An electrical contact consisting of an aluminum contact plate having a depression on one side and a hollow pressure-hardened integral contact projecting from said plate opposite to said depression having a thickness equal to about 40% of the thickness of said plate, said contact being capped by a layer of different contact metal firmly bonded thereto by a solid phase cold weld joint.

4. A method of producing an electrical contact on a contact member of cold pressure weldable metal which consists in placing in a depression of a supporting die and centrally therewith a slug of cold pressure weldable contact metal, said depression conforming to the contour of the contact to be formed and having lateral dimensions less than said member, placing said member upon said die in overlying relation to said depression, and applying to an area of said member having dimensions less than said depression and central with respect thereto a pressure, to form a projecting contact conforming to said depression and to effect a substantial reduction of the metal thickness at said area, thereby to create an intensified interfacial metal flow between said slug and member conducive to spreading and pressure welding the slug metal to the surface of the contact formed.

5. A method of producing an electrical contact on a copper contact member which consists in placing in a depression of a supporting die and centrally therewith a slug of cold pressure weldable contact metal, said depression conforming to the contour of the contact to be formed and having lateral dimensions less than said member, placing said member upon said die in overlying relation to said depression, and applying to an area of said member less than said depression and central with respect thereto a pressure, to form a projecting contact conforming to said depression and to effect a reduction of the metal thickness of about 80 percent at said area, thereby to create an intensified interfacial metal flow between said slug and member conducive to spreading and pressure welding the slug metal to the surface of the contact formed.

6. A method of producing an electrical contact on an aluminum contact member which consists in placing in a depression of a supporting die and centrally therewith a slug of cold pressure weldable contact metal, said depression conforming to the contour of the contact to be formed and having lateral dimensions less than said member, placing said member upon said die in overlying relation to said depression, and applying to an area of said member less than said depression and central with respect thereto a pressure, to form a projecting contact conforming to said depression and to effect a reduction of the metal thickness at said area of about 60 percent, thereby to create an intensified interfacial metal flow between said slug and member conducive to spread and pressure weld the slug metal to the surface of the contact formed.

7. In a method of producing an electrical contact on a contact member of cold pressure weldable metal which consists in placing in a dome-shaped depression of a supporting die and centrally therewith a disc of cold pressure weldable contact metal, said depression conforming to the contour of the contact to be formed and having a diameter less than the dimensions of said member, placing said member upon said die in overlying relation to said depression, and applying to a circular area of said member conforming to said disc and central with respect thereto a pressure, to form a projecting contact conforming to said depression and to effect a substantial reduction of the metal thickness at said area, thereby to create an intensified interfacial metal flow between said disc and member conducive to spreading and pressure welding the disc metal to the surface of the contact formed.

8. A method of producing an electrical contact on a contact member of cold pressure weldable metal which consists in placing in a dome-shaped depression of a supporting die and centrally therewith a disc of cold pressure weldable contact metal, said depression conforming to the contour of the contact to be formed and having a diameter of the order of twice the diameter of said disc and less than the dimensions of said member, placing said member upon said die in overlying relation to said depression, and applying to a circular area of said member substantially equal to and central with said disc a pressure, to form a projecting contact conforming to said depression and to effect a substantial reduction of the metal thickness at said area, thereby to create an intensified interfacial metal flow between said disc and member conducive to spreading and pressure welding the disc metal to the surface of the contact formed.

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