Oct. 26, 1971 L. H. KNOP ET AL 3,614,827

PROCESS FOR EXPLOSIVELY BONDING DISSIMILAR METALS

Filed April 24, 1969

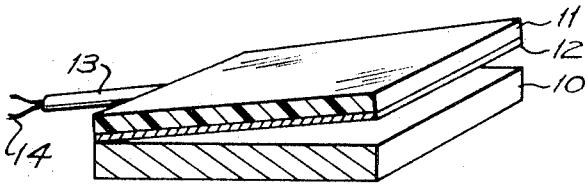


FIG. 1

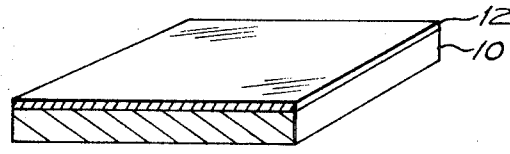


FIG. 2

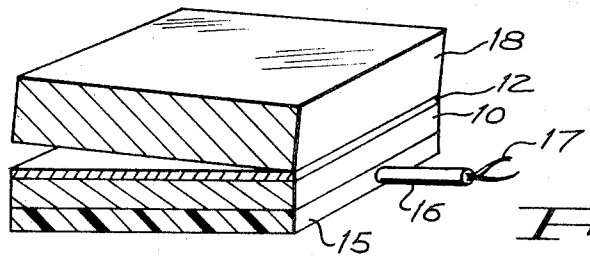


FIG 3

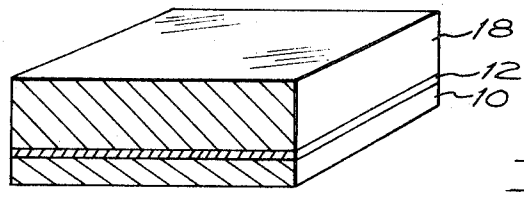


FIG. 4

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3,614,827

Patented Oct. 26, 1971

3,614,827

PROCESS FOR EXPLOSIVELY BONDING DISSIMILAR METALS

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Filed Apr. 24, 1969, Ser. No. 818,910
Int. Cl. B23k 21/00
U.S. Cl. 29—470.1 4 Claims

ABSTRACT OF THE DISCLOSURE

According to the present disclosure, a metal cladding layer of relatively low acoustic impedance is explosively bonded to one surface of the metal of two dissimilar metals which has the higher acoustic impedance. Subsequently, the metal cladding layer is explosively bonded to the other of the two dissimilar metals.

This invention relates to explosive welding, and particularly to methods for explosively welding two dissimilar metals together.

Heretofore, bonded metal systems having dissimilar metals have been produced by explosively welding dissimilar metals together by applying an explosive charge impact to the metal having the lowest acoustic impedance. However, it is not always feasible to apply the explosive charge to the metal having lowest acoustic impedance. For example it may not be practical to apply an explosive charge to the low impedance material if it is in a confined space or if the metal having the lower acoustic impedance is too thick to sustain the detonation velocity.

It is an object to the present invention to provide a method for explosively welding dissimilar metals together wherein the explosive charge may be applied to either metal.

It is another object to the present invention to provide a method for explosively welding dissimilar metals together wherein the explosive charge is applied to the thinner of two metals.

It is another object to the present invention to provide a method of explosively welding dissimilar metals together wherein the explosive charge is applied to the metal having the higher acoustic impedance.

In accordance with the present invention, the metal having the higher acoustic impedance is cladded with a metal having a lower acoustic impedance. Preferably, the cladding metal is the same type of metal as the metal forming the other of the bimetal weld. The present invention is particularly useful for explosively welding dissimilar metals together wherein it is more convenient to apply the explosive charge to the metal having the higher acoustic impedance.

The term "metal" as used herein includes any elemental metal or mixture of elemental metals, for example an alloy.

The above and other features of this invention will be more fully understood in the following detailed description and the accompanying drawings, in which:

FIGS. 1 through 4 inclusive, are perspective views partly in cutaway cross-section, illustrating the method of explosively welding dissimilar metals together in accordance with the presently preferred embodiment of the present invention.

In accordance with the present invention, a sheet **10** of material having a relatively high acoustic impedance is provided, which sheet is to be explosively welded to a sheet of relatively low acoustic material (sheet **18** in FIGS. 3 and 4). A layer **11** of explosion material is applied to a relatively thin layer **12** of material having a relatively low acoustic impedance. Typical explosive materials suitable for use in this invention include dynamite, nitroguainidine and "Du Pont Detasheet" commercially available from E. I. Du Pont de Nemours & Company. Detonator **13** is applied to explosive layer **11** to be initiated by applying an electric charge to wires **14**. An electric charge applied to wire **14** operates detonator **13** thereby detonating layer **11** of explosive to create a jet action behind the explosion as the detonation front moves across layer **12**. Layer **12** is bonded to sheet **10** of relatively high acoustic impedance by the explosion as illustrated in FIG. 2.

During the detonation process, sheet **10** and layer **12** may be contiguous, or they may be separated by a small distance. Furthermore, it may be desirable to position sheet **10** and layer **12** at an angle to each other, which angle converges toward the edge adjacent detonator **13**. By way of example, it has been found that by positioning layer **12** at an angle of about 1° to sheet **10** with the sheets spaced apart by less than about 0.035 inch at the edge nearest detonator **13**, satisfactory results have been obtained.

Next, as illustrated in FIG. 3 a layer **15** of explosive material is applied to the opposite surface of sheet **10** and detonator **16** having wires **17** is attached to generator **15**. Sheet **18** of relative low acoustic impedance metal is positioned adjacent or contigious or at an angle to layer **12**. Preferably sheet **18** is the same metal as layer **12**.

An electric charge is applied to wires **17** thereby operating detonator **16** to detonate layer **15** thereby explosively bonding thin layer **12** to sheet **18**. Hence, the sheet **10** of relative high acoustic impedance metal is explosively bonded by means of thin layer **12** to sheet **18** of relatively low acoustic impedance metal.

The detonation velocity of the explosive may be any velocity suitable for obtaining bonding of the respective layers. By way of example, detonation velocities in the range of 2900 meters per second and 3500 meters/second have been found suitable for many metals. Of course, the detonation velocity may exceed 3500 m./sec. or be less than 2900 m./sec. for some metals.

The process according to the present invention has been performed by cladding aluminum to a sheet of 4130 steel and thereafter cladding the aluminum layer to a sheet of aluminum. Of course other metal systems may be constructed in accordance with the present invention. Typically, cladding layer **12** will have a thickness in the range of about 0.002 and 0.5 inch and sheet **10** of high impedance material will have a thickness of less than about 1 inch.

The bond produced by the present invention is basically a diffusion-type bond, except that the diffusion layer does not form a straight slip plane. Hence, a mechanical bond is also achieved between the layers.

The present invention thus provides a method for explosively bonding dissimilar metals together wherein the explosive charge may be applied to the metal having the higher acoustic impedance instead of to the metal having the lower acoustic impedance material as heretofore utilized. Hence, the present invention thus provides versatility for explosive welding processes. The present invention is effective in operation and is easily performed.

This invention is not to be limited by the embodiment shown in the drawings and described in description, which is given as way of example and not of limitation, but only in accordance with the scope of the appended claims.

What is claimed is:

1. A method of bonding a first metal to a second metal, said first metal having a higher acoustic imped-

ance than said second metal and said first and second metals being dissimilar, said method comprising the steps of covering an exposed surface of a metal cladding layer with a layer of detonating explosive, said metal cladding layer having a lower acoustic impedance than said first metal, initiating said first explosive to explosively bond the opposite surface of sad metal cladding layer to one surface of said first metal, subsequently covering the surface of said first metal opposite said one surface of said first metal which is bonded to said metal cladding layer with a layer of second detonating explosive, and initiating said second detonating explosive to explosively bond the exposed surface of said metal cladding layer to one surface of said second metal without simultaneously applying an explosive force to the surface of said second metal opposite said one surface of said second metal.

2. A method according to claim **1** wherein the metal cladding layer is constructed of the same metal as said second metal.

3. A process for producing a bonded metal system comprising a first metal and a second metal, said first metal having a higher acoustic impedance than said second metal and said first and second metals being dissimilar, said process comprising the steps of covering an exposed surface of a metal cladding layer with a layer of detonating explosive, said metal cladding layer having a lower acoustic impedance than said first metal, initiating said first explosive to explosively bond the opposite surface of said metal cladding layer to one surface of said first metal, subsequently covering the surface of said first metal opposite said one surface of said first metal which is bonded to said metal cladding layer with a layer of second detonating explosive, and initiating said second detonating explosive to explosively bond the exposed surface of said metal cladding layer to one surface of said second metal without simultaneously applying an explosive force to the surface of said second metal opposite said one surface of said second metal.

4. A process according to claim **3** wherein the metal cladding layer is constructed of the same metal as said second metal.

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U.S. Cl. X.R.

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