

1

3,229,364

WELDING OF LAMINAR METALLIC ELEMENTS
Hugh Thomas, Irvine, and William Thornhill Montgomery, Ardrossan, Scotland, assignors to Imperial Chemical Industries Limited, London, England, a corporation of Great BritainNo Drawing. Filed Feb. 25, 1963, Ser. No. 260,872
Claims priority, application Great Britain, Mar. 1, 1962, 8,036/62

10 Claims. (Cl. 29—474.3)

This invention relates to a new method of welding together laminar metallic elements and to welded structures formed thereby.

According to the present invention a method of welding together metal laminae consists in assembling two or more metal laminae into a laminated assembly in which the surfaces of adjacent laminae are in direct contact, placing a layer of high explosive in proximity over each of the two outer faces of the laminated assembly and detonating the explosive, whereby the laminae are welded together at contacting surfaces.

Welding of the metal results from the action of the intense shock waves released on detonation of the explosive. Two such shock waves are generated when the explosive is detonated one wave travelling from each layer of explosive. These shock waves meet within the laminar assembly and the heat generated by their collision is rapidly dissipated within the metal and contributes to the welding process. Detonation of an explosive layer on only one surface of the laminar assembly does not result in satisfactory welding of the laminae.

Any detonating explosive may be used but it is preferable to choose a plastic explosive which can be readily formed into a uniformly thick layer conforming to the shape of the surface over which it is placed. We have found gelatinous detonating explosives containing gelatinised nitroglycerine and explosives containing pentaerythritoltetranitrate or cyclotrimethylenetrinitramine mixed with plastic binder to be convenient. Another very convenient explosive for this purpose is commercial detonating fuse consisting of a thin core of pentaerythritoltetranitrate powder surrounded by a waterproof sheath of synthetic plastic material. This material may be readily placed over the surface to form the required layer and if desired more than one layer of the fuse cord may be employed.

The weight of explosive used per unit of surface area of the metal lamina over which it is placed should preferably be limited to an amount which on detonation will not cause excessive surface damage or cracking of the metal. As a safeguard against surface damage we have found it advantageous to place a layer of inert protective material between the explosive layer and the metal surface to attenuate the shock wave and reduce the effective pressure pulse on the metal surface. Wet cardboard has been found convenient for this purpose. The thicknesses of explosive and protective layers used may be chosen to give the required welding effect while avoiding excessive surface damage. The thickness of the explosive layer required will vary in accordance with the nature of the metal being welded and the thickness of the laminated assembly whereas the thickness of inert material required to protect the surface will vary in accordance with the nature of the outer metal surfaces and the nature and amount of explosive used. The optimum layer thicknesses may be readily obtained by simple experiments.

2

In a preferred modification of the invention the explosive layer is confined by a stemming material, the explosive being disposed between the stemming material and the metal surface or the layer of protective material if the latter is used. Any of the commonly used solid stemming materials such as clay and the like may be used but we have found water to be a particularly convenient stemming material, since its use simply necessitates immersion thereof of the laminated assembly with the explosive charges fixed in place. Precautions should preferably be taken to prevent ingress of water between the explosive layer and the metal surface.

Although the invention may be advantageously applied in welding any metals, since it provides a method of rapidly welding two or more coincident metallic layers over a large area of contact, it is of particular advantage in welding those metals to which the conventional method cannot readily be applied. For example metals such as aluminium and titanium, which may be damaged by prolonged heating, may be readily welded. The parts to be welded may be either of the same or different metals.

The invention may advantageously be used to apply a covering layer of one metal on a base layer of another, or to weld a metallic lining into a hollow metallic body the weld being substantially uniform over the entire area of contact. The method is also applicable to seaming together metallic members by lapping portions of the members, placing an explosive charge on each free surface of the overlapping portion and detonating it. Again this is specially advantageous in forming assembled structures from metals which are difficult to weld by conventional methods.

The invention also includes welded structures formed by the aforescribed method.

The invention is further illustrated by the following examples in which cleaned metal plates were assembled in a laminated assembly, both the free surfaces were covered with a layer of wet greyboard and a layer of explosive was placed over each layer of greyboard. The assembly was firmly tied together by means of adhesive tape placed in a thin polythene bag and immersed in water. Finally the explosive was detonated. For convenience and clarity the details of the examples are set forth below in tabular form. The metal plates used were in all cases 3 millimetres thick except in Examples 14 and 15 where a sheet of aluminium foil 0.02 millimetre thick was placed between two other plates. The greyboard was used in sheets 2 millimetres thick, multiple layers being used in some examples as indicated.

The plastic explosive used in Example 3 was 70 parts powdered pentaerythritoltetranitrate mixed with 30 parts of a binding composition containing 4 parts of nitrocellulose, 3 parts of dibutylphthalate and 23 parts of a dinitrotoluene oil, all parts being by weight.

The detonating fuse used in the remaining examples had a core of powdered pentaerythritoltetranitrate (PETN) 2.5 millimetres in diameter surrounded by a sheath of plasticised polyvinylchloride. The overall diameter of the fuse was 4.75 millimetres and the PETN charge was approximately 3 grams per foot of fuse.

After detonation of the explosive the joints formed between the metal surfaces were subjected to visual and metallurgical tests to determine whether welding had occurred uniformly over the surface and the results of these tests are given in the final column of the table. In all the examples a uniform weld was obtained between the contacting surfaces of the plates.

TABLE

Example	Metals in laminated assembly	Dimensions of Contacting Surfaces (Centimetre)	Explosive Charge on each surface		Number greyboard layers used	Result
			Description and assembly	Loading g./sq. cm.		
1.....	Aluminum-Aluminum.....	5 x 5	1 layer detonating fuse.	0.1	1	Uniform weld.
2.....	do.....	5 x 5	2 layer detonating fuse.	0.2	4	Do.
3.....	do.....	5 x 5	3 millimetre thick layer of plastic explosive.	0.47	1	Uniform weld but final structure somewhat distorted.
4.....	do.....	15 x 20	1 layer detonating fuse.	0.1	1	Uniform weld. Slight distortion of welded structure.
5.....	do.....	15 x 20	2 layers detonating fuse.	0.2	4	Uniform weld.
6.....	Copper-Copper.....	5 x 5	do.....	0.2	1	Do.
7.....	Titanium-Titanium.....	5 x 5	do.....	0.2	1	Do.
8.....	Stainless steel-Stainless steel.....	5 x 5	4 layers detonating fuse.	0.4	1	Do.
9.....	Brass-Aluminum.....	5 x 5	2 layers detonating fuse.	0.2	1	Do.
10.....	Copper-Mild Steel.....	5 x 5	4 layers detonating fuse.	0.4	1	Do.
11.....	Aluminum-Mild steel.....	5 x 5	2 layers detonating fuse.	0.2	1	Do.
12.....	Aluminum-stainless steel.....	5 x 5	do.....	0.2	1	Do.
13.....	Copper-Aluminum-Brass.....	5 x 5	do.....	0.2	1	Uniform weld at both joints.
14.....	Brass-Aluminum foil-Brass.....	5 x 5	4 layers detonating fuse.	0.4	1	Do.
15.....	Aluminum-Aluminum Foil-Stainless steel.....	5 x 5	2 layers detonating fuse.	0.2	1	Do.

What we claim is:

1. A method of welding together metal laminae comprising: assembling two metal laminae with the surface of each lamina in direct contact with substantially the entire opposed surface of the other lamina and welding together the engaged surfaces at least partially by heat generated by colliding shock waves, said welding being effected by placing a layer of high explosive in proximity over each of the outer surfaces of the assembly, the layers of explosive having the same velocity of detonation and being equispaced from the plane of engagement of the metal surfaces, and detonating the explosive layers simultaneously.

2. A method of welding in accordance with claim 1 wherein the high explosive is a plastic explosive.

3. A method of welding in accordance with claim 2 wherein the plastic explosive is one containing gelatinised nitroglycerine.

4. A method of welding in accordance with claim 2 wherein the plastic explosive is mixed with a plastic binder and is selected from the group consisting of pentaerythritoltetranitrate and cyclotrimethylenetrinitramine.

5. A method of welding in accordance with claim 1 wherein the high explosive is detonating fuse consisting of a thin core of pentaerythritoltetranitrate surrounded by a waterproof sheath of synthetic plastic material.

6. A method of welding in accordance with claim 1 wherein a layer of inert protective material is placed between the explosive layer and the metal surface.

7. A method of welding in accordance with claim 1 wherein the high explosive layer is confined by a stemming material.

8. A method of welding in accordance with claim 7 wherein the laminated assembly with the explosive charges fixed thereon is immersed in water and the explosive is detonated while the assembly is thus immersed.

9. A method of welding in accordance with claim 1 wherein the laminae are constructed of a metal selected from the group consisting of aluminum and titanium.

10. A method of lining a hollow metallic body with a metallic lining which consists in welding the lining on to the body by a welding method in accordance with claim 1.

References Cited by the Examiner

UNITED STATES PATENTS

3,023,462	3/1962	Taylor et al.	
3,036,374	5/1962	Williams	29—421
3,121,283	2/1964	Kaempfen	29—471.1
3,137,937	6/1964	Cowan et al.	29—487 XR

JOHN F. CAMPBELL, *Primary Examiner*.