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(54) **METHOD OF TYING TWO OR MORE COMPONENTS TOGETHER**

VERFAHREN ZUM ZUSAMMENBINDEN VON ZWEI ODER MEHR KOMPONENTEN

PROCEDE DE LIAISON D'AU MOINS DEUX COMPOSANTS

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Corporate Patents 06820, M1.7
405 08 Göteborg (SE)

(56) References cited:
US-A- 2 909 651 US-A- 3 524 042
US-A- 3 797 096

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Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a method of tying two or more components together according to the preamble of claim 1.

[0002] Such a method can be used for the manufacture of a number of products, but it will hereafter be described by way of example in no way restrictive of the invention how the method can be applied in order to tie a number of components together, so that these form a cohesive and self-supporting construction with a view to joining the components together, for example by soldering, at a subsequent stage of manufacture.

DESCRIPTION OF THE PRIOR ART

[0003] In the aircraft industry, for example, there is a need to join various components, such as plates, together by soldering or some other method of joining, for the manufacture of various constructions. In order to facilitate the soldering of a number of plates these must be fixed in relation to one another during the soldering phase. A fixture or a so-called soldering jig can be used for this purpose. If the construction comprises a large number of components, however, or if it has a complex geometry, this will place great demands on the design of the soldering jig. In addition to the fact that the complexity of the soldering jig leads to high production costs, it will also be difficult to handle at the soldering stage.

[0004] One way of dispensing with the use of a soldering jig is instead to preassemble the plates into a self-supporting construction prior to soldering. Such preassembly can be achieved by welding or riveting the components together. When using brittle materials, however, such as intermetallic alloys, for example TiAl, NiAl and FeAl, conventional welding and riveting can have an adverse effect on the material and on the characteristics of the finished product, due to the occurrence of cracking.

[0005] For TIG and EB welding of intermetallic alloys a complicated preheating and/or postheating of parts of the construction or the entire construction are required in order to avoid cracking and/or expansion in the weld seam or in the parent material as a result of large temperature gradients. Both the process and the equipment needed to carry out such heat treatments are expensive.

[0006] Conventional hot-riveting can also lead to large temperature gradients in the construction, resulting in cracking. Furthermore, riveting with rivets made of conventional material, such as IN600 or the like, can lead to thermal fatigue cracking due to large differences in the coefficient of thermal expansion between the material in the rivet and the material in the components made from intermetallic compounds that are to be riveted together. At higher temperatures, differences in the thermal expansion of the materials will have an effect on the force with which the rivet holds the components together. If the

rivet has a higher coefficient of thermal expansion than the components held together by the rivet, at higher temperature the force with which the components are held together will be reduced. In addition, alloys of different composition in rivet and plates lead to the formation of undesirable brittle phases in the material closest to the rivet hole during subsequent soldering of the components, for example.

[0007] US 2,909,651 discloses a method using heat and pressure for the forming of metal elements, particularly the heading of titanium rivets. The method utilizes squeeze pressure and requires heating of the metal to working temperature in conjunction therewith.

15 OBJECT OF THE INVENTION AND SUMMARY OF THE INVENTION

[0008] The object of the present invention is to provide a method of the type defined in the introductory part, in which method at least one of the aforementioned disadvantages of such hitherto known methods is substantially mitigated, that is to say to provide a method of tying components together by means of a fastener, by which method even particularly brittle materials can be tied together without unduly adverse effects on the material in the form of cracking or the formation of undesirable brittle phases in the material.

[0009] According to the invention this object is achieved by a method according to claim 1. In this method the fastener is essentially heated only during the deformation phase of the fastener. This minimizes the heat transfer from the fastener to the components that are to be tied together. Heat only has to be supplied to the fastener and only to the extent needed to deform the fastener to the required degree under the relevant load. This in turn means that the components can be kept at a relatively low temperature without large temperature gradients and that the characteristics of the material of the components can remain largely unaffected during tying. In this way it is also possible to make efficient use of the quantity of energy used for tying purposes.

[0010] A major advantage of the method according to the invention is that it is possible to use non-preheated components and non-preheated fasteners. Prior to tying, the components and the fastener may be at ambient temperature, such as normal room temperature, or a temperature close to this. This makes it possible to dispense with costly processes and devices for the heat treatment of components prior to and/or after tying, whilst tying can be carried out without significant adverse effects on the components.

[0011] Further, the fastener is first pressure-loaded and the fastener then heated whilst maintaining the pressure loading. In this way the initiation of the fastener deformation sequence can be controlled with the supply of heat to the fastener, the heat being suitably obtained by passing an electrical current through the fastener. The use of electrical current for transferring heat to the fas-

tener has the advantage that it is relatively easy to control, that is to say the current strength and the time for which the current must flow through the fastener can be adjusted to the relevant material and dimensional parameters in order to produce the required heat transfer.

[0012] In a preferred embodiment of the method according to the invention the fastener is pressure-loaded by means of a tool and after deformation of the fastener the mechanical contact between the pressure loading tool and the fastener is maintained to allow cooling of the fastener through the transfer of heat from the fastener to the pressure loading tool. The excess heat present in the deformed fastener can thereby largely be absorbed by the pressure loading tool, which can be cooled in order to promote such heat transfer, and the undesirable transfer of heat to the components being tied by the fastener can in this way be further reduced.

[0013] A suitable tool for carrying out the tying is a combined pressure loading and heating tool having two electrodes, between which the fastener is placed and by means of which electrodes a pressure can be applied to the fastener whilst heat can be delivered to the fastener by an electrical current flowing between the electrodes during the fastener deformation phase. Heat can furthermore be dissipated from the fastener following the deformation phase in that the electrodes have a lower temperature than the fastener.

[0014] Other advantages of the method according to the invention are set forth in the detailed description below and in other dependent claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] Preferred embodiments of the invention will be described below by way of example, with reference to drawings attached.

[0016] In the drawings:

Fig. 1 is a schematic cross-section illustrating how a fastener for tying two components together is pressure-loaded by means of two electrodes,

Fig. 2 is a schematic cross-section corresponding to that in Fig. 1 illustrating how a voltage is applied over the fastener for deforming the fastener,

Fig. 3 is a schematic cross-section corresponding to that in Fig. 1 illustrating how the voltage has been removed after deformation of the fastener whilst maintaining the contact between the fastener and the electrodes, and

Fig. 4 is a schematic side view of three different examples of fasteners for use in the method according to the invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS OF THE INVENTION

[0017] The method according to the invention will now be described in more detail with reference to figures 1 to 4:

[0018] Two or more components 1, 2 which are to be tied are provided with a through hole and the components 1, 2 are placed so that these holes overlap one another in order to receive a fastener 3 in the holes. The fastener 3 has longitudinal extent exceeding the total thickness of the components 1, 2, so that a part 4 of the fastener protrudes outside the holes and the components and is thus exposed for deformation, that is for compressing towards the nearest component 1 with simultaneous expansion of the cross-section of this part 4 of the fastener 3. The fastener 3 placed in the holes is pressure-loaded mechanically and heated in order to deform the fastener 3, thereby tying the components 1, 2 together.

[0019] In the method according to invention the fastener 3 is heated essentially only during the fastener deformation phase in order to minimize the heat transfer from the fastener 3 to the components 1, 2 to be tied. The expression "essentially only during the fastener deformation phase" is intended to signify that heat is not supplied before or after the deformation of the fastener in order to produce the tie. The fastener 3 is therefore not preheated when placing this in the holes in the components and no preheating in the conventional sense occurs prior to the deformation phase, nor do the components 1, 2 need to be preheated. As will be apparent from the following description, however, a certain heat transfer to the fastener 3 may occur prior to deformation, owing to the fact that the deformation does not occur instantaneously when heat is supplied to the fastener, but a certain delay probably occurs between the supplying of heat and the deformation. Similarly a certain heat supply may be present just after deformation, due to a possible hysteresis in the system. The aim, however, is to minimize heat transfer to the fastener 3 and hence to the components 1, 2 after deformation of the fastener has been carried out.

[0020] Fig. 1 shows how a rivet 3 for tying two plates 1, 2 together is loaded. A load F which is sufficient to deform the rivet 3 in the hot state is applied to the fastener 3 by moving two electrodes 5, 6 in a combined pressure loading and heating tool 7 in a straight line relative to one another and towards one another with the rivet 3 arranged between the electrodes. One of the electrodes 5 can be suitably fixed and accommodate a headed end 8 of the rivet 3, for example, whilst the other electrode 6 is designed for rectilinear movement towards (and away from) the other end 9 of the rivet and the first electrode 5. Alternatively, both electrodes 5, 6 may be designed for rectilinear movement.

[0021] Fig. 2 shows how in a subsequent stage, by means of a voltage source 15, an electrical voltage is applied over the electrodes 5, 6 and thereby over the

rivet 3. This involves passing a current through the pressure-loaded rivet 3 so that the rivet is heated, with the result that the rivet 3 is deformed due to the pressure loading and the increased temperature of the rivet, following which the current is immediately withdrawn and the heat supply to the rivet 3 ceases. Due to the fact that a certain delay can occur between the current and generation of heat in the rivet 3, the current supply may in certain cases have to be cut off before complete deformation has occurred, in order to avoid an undue amount of heat being transferred to the rivet 3. The current strength and the duration of the current are naturally adjusted to the different conditions prevailing during the actual riveting operation, such as the dimensions and material of the rivet 3, which in turn depend on the material and dimensions of the plates 1, 2. The duration of the current often ranges from fractions of a second up to about one second. With regard to the voltage source 15, it is possible to use both an alternating current voltage source and a direct current voltage source in order to generate the required current.

[0022] Thereafter, as shown in Fig. 3, the load on the rivet 3 can be maintained, or at least the mechanical contact between the electrodes 5, 6 and rivet 3 can be maintained even if the load F is reduced or removed, in order to cool the rivet 3 by means of the electrodes 5, 6, that is to say in order that any excess heat in the rivet 3 will be transferred to the electrodes rather than to the plates 1, 2. It is advantageous, however, in order to prevent cracking, that the load be maintained during the cooling process. Such cooling of the rivet 3 is typically completed in one to a few seconds. In order to facilitate the transfer of heat from the rivet 3 to the pressure loading tool 7 after deformation of the rivet 3, the pressure loading tool 7 can be cooled by means of conventional equipment. The method, or at least the heating of the fastener 3, is suitably performed in an atmosphere containing an inert gas, in order to minimize oxidation of the fastener 3 and/or the components 1, 2, which in practice to some extent probably also involves placing the components 1, 2 to be tied in such an atmosphere.

[0023] After deformation, that is to say upsetting of the rivet 3, the electrodes 5, 6 and the components 1, 2 can be moved in relation to one another in order, where required, to permit riveting in another position of the components 1, 2 using a further rivet.

[0024] If, due to particularly unfavorable geometry and/or unfavorable dimensions, there should still be a risk of cracking or of other undesirable effect on the material, the risk can be further reduced by using a protective component 10, in the form of a rivet washer 10, for example. As illustrated schematically in Fig. 1, the rivet washer 10 may be arranged round the rivet 3 at the deformation end 9 of the rivet up against one of the components 1. In this way, in subsequent deformation of the rivet 3 direct contact between the hot deformed material of the rivet and the plate 1 will be prevented, which means that the greatest temperature gradient will be between

the rivet 3 and the rivet washer 10 rather than between the rivet 3 and the plate 1.

[0025] The fastener 3 illustrated in Fig. 1, 2 and 3 may be designed in a number of different ways without departing from the scope of the invention. Although the fastener 3 in the example described above has an elongate section 11 with circular cross-section and a head 12 at one end 8, other embodiments of the fastener are possible. For example, the head 12 might be eliminated even though this in turn requires more advanced riveting equipment in order to control the deformation of the rivet. Should the rivet 3 be provided with a head, this may be designed both for flush riveting and raised riveting. Three examples of different rivets 3a, 3b, 3c having different types of heads 12, 12b, 12c are illustrated in Fig. 4, of which one rivet 3b is designed for flush riveting.

[0026] Other conventional equipment can naturally also be used together with the method according to the invention. For example, equipment for pressing the plates together during the riveting operation may be used if so required.

[0027] The piercing of holes in the components 1, 2, required for tying them together can be performed by conventional methods such as drilling, spark erosion or water cutting. The shape and size of the holes and the shape and size of the rivet are matched to one another so that the desired riveted connection can be achieved by deformation of the rivet when this is placed in the holes. Holes and rivets of circular cross-section with substantially the same diameter are preferably used, but it is also possible to use rivets of different cross-section. Piercing can be performed simultaneously for the components to be tied, or separately for each component. In order to facilitate joining of the components in a subsequent treatment of the components, a layer of material, such as a soldering foil (not shown) can be arranged between the components before or after piercing the holes. The soldering foil is then used for soldering the components together. By soldering the components together it is possible to obtain a permanent product having a considerably higher load transmission capacity compared to the temporary product simply riveted together.

[0028] It should also be added that multiple rivets can be riveted essentially simultaneously through the use of more than one pressure loading tool or one pressure loading tool that can be applied to a number of rivets at a time, for example one tool having more than one pair of electrodes.

[0029] The method according to the invention is particularly well-suited to tying brittle materials together, such as intermetallic alloys, and rivets of a material from the group of intermetallic alloys are preferably used for this purpose. Examples of alloys in the intermetallic alloys category are TiAl, NiAl and FeAl. Experiments aimed at manufacturing products suitable for use in the aircraft industry using the method according to the invention have successfully been carried out. For example, the method has been applied to plates made of TiAl with a

thickness of 1 mm. Rivets made of TiAl are used for tying the plates together and a soldering foil Ticuni 70 with a thickness of 50 μm for soldering the plates together after riveting.

[0030] It should be emphasized that the invention is not limited to embodiments of the invention described herein but only by the following claims. Given familiarity with the idea of the invention, a number of modifications within the scope of the invention will probably be obvious to a person skilled in the art.

Claims

1. A method of tying two or more components (1, 2) together by means of a fastener (3), in which each component (1, 2) is provided with a hole and the components are placed so that the holes overlap one another in order to receive the fastener (3) in the holes, the fastener (3) placed in the holes being mechanically pressure-loaded and heated in order to deform the fastener, thereby tying the components (1, 2) together, **characterized in that** the fastener (3) is first pressure-loaded and then heated whilst maintaining the pressure loading, said fastener (3) being heated essentially only during the fastener deformation phase in order to minimize the heat transfer from the fastener to the components (1, 2) being tied, and **in that** tying is carried out with both the fastener (3) and the components (1, 2) made of the same or similar alloys included in the intermetallic alloys group of materials.
2. The method as claimed in claim 1, **characterized in that** the fastener (3) is pressure-loaded by means of a tool (7) and that the mechanical contact between the pressure loading tool (7) and the fastener (3) is maintained after deformation of the fastener, in order to cool the fastener by transferring heat from the fastener (3) to the pressure loading tool (7).
3. The method as claimed in claim 2, **characterized in that** the pressure loading tool (7) is cooled in order to facilitate heat transfer from the fastener (3) to the pressure loading tool after deformation of the fastener.
4. The method as claimed in any one of the preceding claims, **characterized in that** a protective component (10) is arranged at the deformation end (9) of the fastener (3) in order, during deformation of the fastener (3), to prevent direct contact between the hot-deformed material of the fastener and the component (1) which is arranged nearest to the deformation end (9) of the fastener (3).
5. The method as claimed in any one of the preceding claims, **characterized in that** the components (1,

2) are tied together in a non-preheated state.

6. The method as claimed in any one of the preceding claims, **characterized in that** the fastener (3) is applied in the holes in a non-preheated state.
7. The method as claimed in any one of the preceding claims, **characterized in that** the fastener (3) is pressure-loaded and heated using a combined pressure loading and heating tool (7).
8. The method as claimed in claim 7, **characterized in that** the fastener (3) is pressure-loaded between two electrodes (5, 6) of the combined pressure loading and heating tool (7).
9. The method as claimed in any one of the preceding claims, **characterized in that** the fastener (3) is heated by passing an electrical current through the fastener (3).
10. The method as claimed in any one of the preceding claims, **characterized in that** the fastener (3) is heated in an atmosphere containing an inert gas in order to minimize oxidation of the fastener (3) and/or the components (1, 2).
11. The method as claimed in any one of the preceding claims, **characterized in that** prior to deformation of the fastener (3), a layer of material, such as a soldering foil, is arranged between the components (1, 2) in order to join the components together by means of the layer of material in a subsequent process.
12. The method as claimed in any one of the preceding claims, **characterized in that** the components (1, 2) are at least temporarily tied together to form a self-supporting construction with the components substantially fixed to one another, before being joined to form an intended load-transmitting construction element at a subsequent stage of manufacture.
13. The method as claimed in claim 12, **characterized in that** the components (1, 2) are joined by soldering.

Patentansprüche

1. Verfahren zum miteinander Verbinden von zwei oder mehreren Komponenten (1, 2) mittels eines Befestigungselements (3), bei dem jede Komponente (1, 2) mit einem Loch versehen wird und die Komponenten so angeordnet werden, dass die Löcher einander überlappen, um das Befestigungselement (3) in den Löchern aufzunehmen, wobei das in den Löchern angeordnete Befestigungselement (3) mechanisch druckbelastet und erwärmt wird, um das Befesti-

- gungselement zu verformen, wodurch die Komponenten (1, 2) miteinander verbunden werden, **dadurch gekennzeichnet, dass** das Befestigungselement (3) zuerst druckbelastet und dann erwärmt wird, während die Druckbelastung aufrecht erhalten wird, wobei das Befestigungselement (3) im Wesentlichen nur während der Befestigungselement-Verformphase erwärmt wird, um die Wärmeübertragung von dem Befestigungselement auf die verbundenen Komponenten (1, 2) zu minimieren, und dass die Verbindung sowohl mit einem Befestigungselement (3) als auch mit Komponenten (1, 2) durchgeführt wird, die aus den gleichen oder ähnlichen Legierungen hergestellt sind, die in der intermetallischen Legierungsgruppe von Materialien enthalten sind.
2. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, dass** das Befestigungselement (3) mittels eines Werkzeugs (7) druckbelastet wird und dass der mechanische Kontakt zwischen dem Druckbelastungswerkzeug (7) und dem Befestigungselement (3) nach der Verformung des Befestigungselements aufrecht erhalten wird, um das Befestigungselement durch Übertragung von Wärme von dem Befestigungselement (3) auf das Druckbelastungswerkzeug (7) zu kühlen.
 3. Verfahren nach Anspruch 2, **dadurch gekennzeichnet, dass** das Druckbelastungswerkzeug (7) gekühlt wird, um eine Wärmeübertragung von dem Befestigungselement (3) auf das Druckbelastungswerkzeug nach Verformung des Befestigungselements zu erleichtern.
 4. Verfahren nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** eine Schutzkomponente (10) an dem Verformungsende (9) des Befestigungselements (3) angeordnet wird, um während der Verformung des Befestigungselements (3) einen direkten Kontakt zwischen dem heißverformten Material des Befestigungselements und der Komponente zu verhindern, die dem Verformungsende (9) des Befestigungselements (3) am nächsten liegt.
 5. Verfahren nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** die Komponenten (1, 2) in einem nicht vorerwärmten Zustand miteinander verbunden werden.
 6. Verfahren nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** das Befestigungselement (3) in den Löchern in einem nicht vorerwärmten Zustand angebracht wird.
 7. Verfahren nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** das Befestigungselement (3) unter Verwendung eines kombinierten Druckbelastungs- und Erwärmungswerkzeugs (7) druckbelastet und erwärmt wird.
 8. Verfahren nach Anspruch 7, **dadurch gekennzeichnet, dass** das Befestigungselement (3) zwischen zwei Elektroden (5, 6) des kombinierten Druckbelastungs- und Erwärmungswerkzeugs (7) druckbelastet wird.
 9. Verfahren nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** das Befestigungselement (3) durch Durchleitung eines elektrischen Stroms durch das Befestigungselement (3) erwärmt wird.
 10. Verfahren nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** das Befestigungselement (3) in einer Atmosphäre erwärmt wird, die ein inertes Gas enthält, um eine Oxidation des Befestigungselements (3) und/oder der Komponenten (1, 2) zu minimieren.
 11. Verfahren nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** vor der Verformung des Befestigungselements (3) eine Materialschicht, wie z.B. eine Lötfolie, zwischen den Komponenten (1, 2) angeordnet wird, um die Komponenten mittels der Materialschicht in einem darauffolgenden Prozess zusammen zu fügen.
 12. Verfahren nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** die Komponenten (1, 2) wenigstens zeitweise miteinander verbunden werden, um eine selbsttragende Konstruktion zu bilden, bei der die Komponenten im Wesentlichen miteinander befestigt sind, bevor sie zusammen gefügt werden, um ein bestimmtes lastübertragendes Konstruktionselement bei einer folgenden Herstellungsstufe zu bilden.
 13. Verfahren nach Anspruch 12, **dadurch gekennzeichnet, dass** die Komponenten (1, 2) durch Löten zusammen gefügt werden.

Revendications

1. Procédé de liaison de deux composants ou plus (1, 2) ensemble au moyen d'une fixation (3), dans lequel chaque composant (1, 2) est muni d'un trou, et les composants sont placés de sorte que les trous se chevauchent l'un l'autre pour recevoir la fixation (3) dans les trous, la fixation (3) placée dans les trous étant chargée par pression mécaniquement et chauffée pour déformer la fixation, en liant ainsi les composants (1, 2) ensemble, **caractérisé en ce que** la fixation (3) est premièrement chargée par pression et ensuite chauffée tout en maintenant la charge par

- pression, ladite fixation (3) étant chauffée essentiellement uniquement pendant la phase de déformation de fixation pour minimiser le transfert de chaleur depuis la fixation vers les composants (1, 2) liés, et **en ce qu'**une liaison est effectuée avec la fixation (3) et les composants (1, 2) constitués des mêmes alliages ou d'alliages similaires inclus dans le groupe de matériaux d'alliages intermétalliques.
2. Procédé selon la revendication 1, **caractérisé en ce que** la fixation (3) est chargée par pression au moyen d'un outil (7), et **en ce que** le contact mécanique entre l'outil de chargement par pression (7) et la fixation (3) est maintenu après déformation de la fixation, pour refroidir la fixation en transférant de la chaleur depuis la fixation (3) vers l'outil de chargement par pression (7). 5
 3. Procédé selon la revendication 2, **caractérisé en ce que** l'outil de chargement par pression (7) est refroidi pour faciliter un transfert de chaleur depuis la fixation (3) vers l'outil de chargement par pression après déformation de la fixation. 10
 4. Procédé selon l'une quelconque des revendications précédentes, **caractérisé en ce qu'**un composant de protection (10) est agencé au niveau de l'extrémité de déformation (9) de la fixation (3) pour, pendant une déformation de la fixation (3), empêcher un contact direct entre le matériau déformé à chaud de la fixation et le composant (1) qui est agencé le plus proche de l'extrémité de déformation (9) et la fixation (3). 15
 5. Procédé selon l'une quelconque des revendications précédentes, **caractérisé en ce que** les composants (1, 2) sont liés ensemble dans un état non pré-chauffé. 20
 6. Procédé selon l'une quelconque des revendications précédentes, **caractérisé en ce que** la fixation (3) est appliquée dans les trous dans un état non pré-chauffé. 25
 7. Procédé selon l'une quelconque des revendications précédentes, **caractérisé en ce que** la fixation (3) est chargée par pression et chauffée en utilisant un outil de chargement par pression et de chauffage combiné (7). 30
 8. Procédé selon la revendication 7, **caractérisé en ce que** la fixation (3) est chargée par pression entre deux électrodes (5, 6) de l'outil de chargement par pression et de chauffage combiné (7). 35
 9. Procédé selon l'une quelconque des revendications précédentes, **caractérisé en ce que** la fixation (3) est chauffée en faisant passer un courant électrique à travers la fixation (3). 40
 10. Procédé selon l'une quelconque des revendications précédentes, **caractérisé en ce que** la fixation (3) est chauffée dans une atmosphère contenant un gaz inerte pour minimiser une oxydation de la fixation (3) et/ou des composants (1, 2). 45
 11. Procédé selon l'une quelconque des revendications précédentes, **caractérisé en ce qu'**avant une déformation de la fixation (3), une couche de matériau, comme une feuille de matériau de soudage, est agencée entre les composants (1, 2) pour relier les composants ensemble au moyen de la couche de matériau dans un processus consécutif. 50
 12. Procédé selon l'une quelconque des revendications précédentes, **caractérisé en ce que** les composants (1, 2) sont au moins temporairement liés ensemble pour former une construction autoportante avec les composants sensiblement fixés l'un à l'autre, avant d'être reliés pour former un élément de construction de transmission de charge prévu à un stade de fabrication ultérieur. 55
 13. Procédé selon la revendication 12, **caractérisé en ce que** les composants (1, 2) sont reliés par soudage.

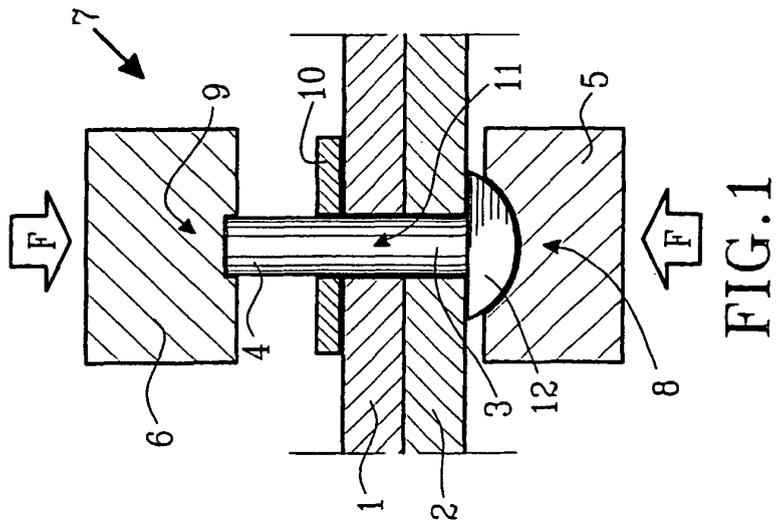


FIG. 1

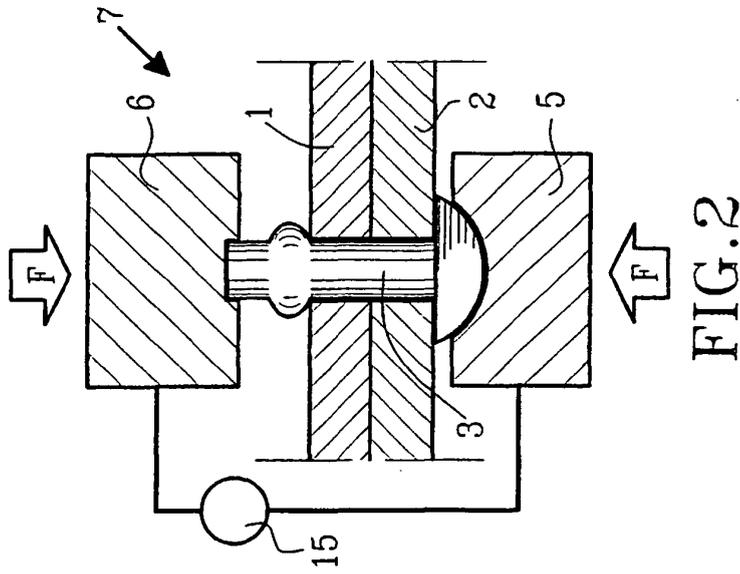


FIG. 2

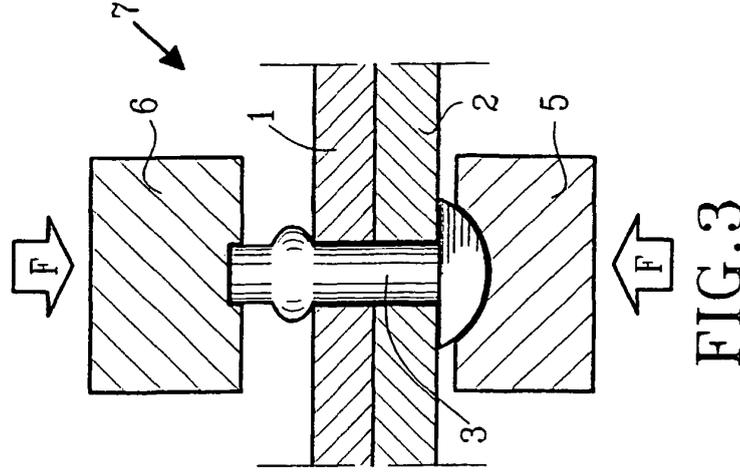


FIG. 3

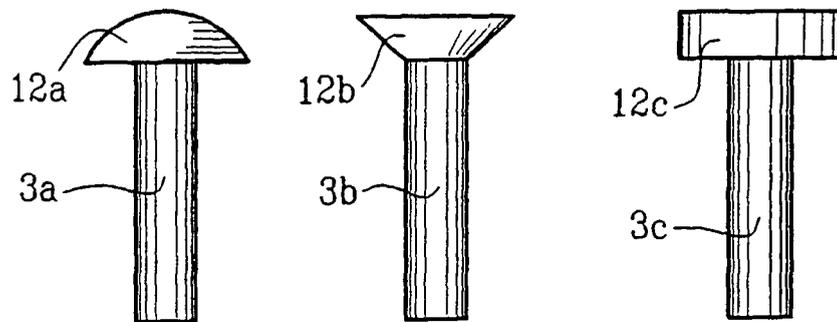


FIG.4

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 2909651 A [0007]