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METHOD AND APPARATUS FOR JOINING TWO MEMBERS IN END-TO-END RELATIONSHIP

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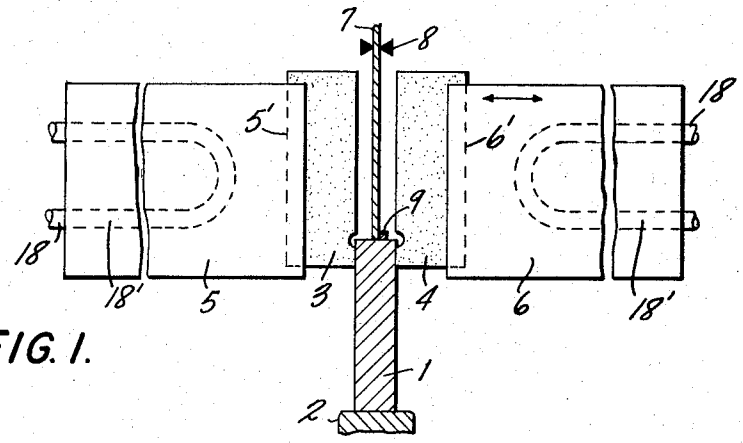


FIG. 1.

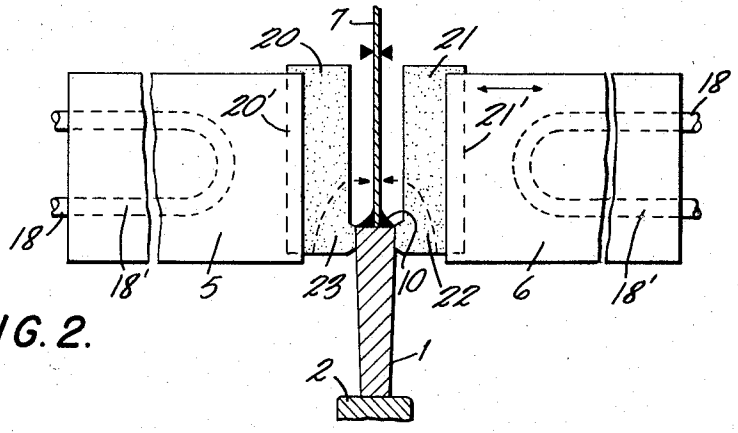


FIG. 2.

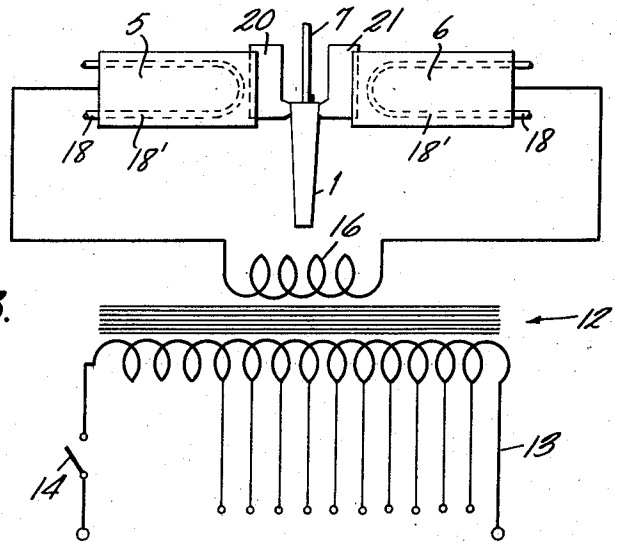


FIG. 3.

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METHOD AND APPARATUS FOR JOINING TWO MEMBERS IN END-TO-END RELATIONSHIP

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7 Claims. (Cl. 219—85)

This invention relates to fusion bonding and more particularly to the means and methods for joining in end-to-end relationship two elements of very different sizes; one element being of low thermal or heat content capacity and having a large surface area, for example, a strip of metal, and the other element having a larger cross-section and therefore greater heat content or heat holding capacity.

It is a principal object of the invention to provide a simple method for fusion bonding two workpieces of substantially different sizes and therefore of different heat holding capacity or heat content and more particularly to provide a simple and effective method for manufacturing commutator segments for rotary electrical machinery and having end-connectors or conductors in the form of strips bonded endwise thereto.

Another object of the invention is to provide a method for joining the strip conductors to the commutator segments in end-to-end relationship without heating or softening a large portion or area of the commutator thereby retaining the initial hardness of the commutator segment giving it excellent wear characteristics in the zone or area on which the brushes make frictional contact.

A feature of the method in accordance with the invention is that the element of greater thermal content is heated by direct contact with incandescent electrodes while the element or workpiece of low thermal or heat content is heated by radiation from the same incandescent electrodes.

Another feature of the method is that the element or workpiece of low heat content or heat holding capacity is preferably placed between the faces of two graphite electrodes without being in contact with them. The faces of the electrodes are disposed approximately parallel to the surface or sides of said workpiece of low thermal content and being sligthly wider than said workpiece. The element or workpiece of greater thermal content is placed in end-to-end relation to the element of low heat content and is clamped between the ends or faces of the graphite electrodes. A piece of suitable filler metal is disposed near the point of abutment of the two elements. A heavy electric current is passed through the electrodes and the element of greater heat content, whereby the graphite electrodes, having a high electrical resistivity, are heated rapidly adjacent their areas making contact with the larger element or workpiece. Due to the good thermal conductivity of graphite, the heat which is developed at the contact areas raises to incandescence the inner faces of the electrodes next adjacent to the surface of the element of low heat holding capacity and heats up this element by radiation, while the larger element is heated by direct contact with the electrodes as well as by the current passing through it.

Other objects, features and advantages of the invention will be understood from the following description and claims in conjunction with the accompanying drawings which illustrate by way of example a preferred embodiment of the means and method and in which

Fig. 1 is a side view of a first embodiment of the electrode according to the invention and shows the manner in which the workpieces are disposed and illustrates a condition before the application of current to said electrodes.

Fig. 2 is a side view of a modified embodiment of the electrodes of Fig. 1 and shows a condition after the application of current to the electrodes and the melting of the filler metal.

Fig. 3 is a simplified schematic electrical diagram of the apparatus for carrying out the invention and illustrates the position of the electrodes and workpieces in the electrical circuit.

While the present invention is herein described with reference to the manufacturing of commutator segments it will be understood that the invention is not limited to this particular function. Moreover the invention is equally applicable to the joining of strips of metal and cylindrical or tubular metallic members.

It will be understood that the terms fusion bonding and welding are hereinafter employed as equivalent generic terms including such operations as brazing, braze welding, joining or uniting metallic members by use of hard solders and alloy filler metals wherein the filler metal melting point is lower than that of the metal or metals being formed.

Referring to the drawings in which similar parts or members have the same reference numerals and wherein is shown a welder adapted to carry out the method according to the invention and in which (Figs. 1 and 2) a commutator segment **1** rests on a work rest **2** adjustable as to height by means not shown. The segment **1** is releasably clamped and held between the lower end portions of two graphite electrodes **3** and **4** carried by electrode holders **5** and **6**. It will be understood that the movable jaws or clamping elements of known standard welders may be replaced by the holders **5** and **6** provided with dovetail slots **5'** and **6'** respectively for removably mounting the graphite electrodes thereon. The holders are relatively separable, at least one of which is selectively movable in a longitudinal direction by a fluid-operated cylinder (not shown) in known manner.

A metal strip **7** consisting of a strip conductor to be joined in end-to-end relationship with the commutator segment **1** is disposed resting on the end of the wider segment **1** and releasably held in fixed vertical position by fingers **8** shown schematically and which are relatively separable by means not shown. A piece of suitable filler metal **9** (Fig. 1) having a melting point lower than members **1** and **7**, is laid on the end of segment **1** alongside of the bottom end of the strip **7** as shown. Upon application of current to the electrodes **5** and **6**, as later herein described, the filler metal **9** is melted and forms (Fig. 2) a concave meniscus **10** fusion bonding or joining the segment **1** and strip **7**.

The welding apparatus (Fig. 3) is provided in known manner with a transformer **12** having its primary winding **13** connected to a source of power (not shown) and is adapted for being energized selectively by closing a switch **14**. It will be understood that the operating cycle is perferably automatically controlled and for this purpose the welder is provided with control relays etc. (not shown) in known manner.

The transformer provides current through a secondary winding **16** connected to the electrode holders as shown. The holders **5**, **6** are each cooled by circulating a cooling fluid, as for example water, through tubes **18** and passageways **18'**.

In establishing an operating cycle it has been found that it is best not to control the cycle by means of a characteristic secondary current for a particular job at

hand. Since the resistance of the graphite electrodes varies greatly in dependence of the temperatures reached during the course of a fusion bonding or welding operation it is practically impossible to speak of a characteristic secondary current.

Accordingly the cycle is controlled by controlled the secondary voltage or voltage applied across the member 1 for a predetermined period of time as a function of the size of the members to be joined. As for example, a commutator segment having a thickness of six millimeters to be joined to a strip twenty millimeters wide and two millimeters thick requires a secondary voltage of 4.9 volts applied for a period of about eleven seconds. A segment having a thickness of ten millimeters to be joined to a strip twenty-five millimeters wide and three millimeters thick requires a secondary voltage applied during a period of about eighteen seconds.

The electrodes are releived as shown in Fig.1 in order to provide an adequate contact area and to preclude overheating the upper edges of the segment 1 and thus provide localized heating of the segment without overheating any portion thereof. A more complicated shape of electrodes 20, 21 are provided with protruding contact surfaces as shown in Figs. 2 and 3 in order to ensure well-defined contact surfaces for making positive contact with the commutator segment 1.

It has been found that the electrodes should preferably be made as wide as the width of the strip 7 for optimum operation. It will be understood that the use of dovetail slots on the ends of the holders 5, 6, as stated heretofore, provides positive electrical contact with the holders. The electrodes are inserted from the upper end of the slots and they rest at the lower end of the slots 5', 6', 20' 21' as shown. The erosion or wear of the graphite electrodes is quite slow and the protuberances and relieved contact areas are provided for purposes of providing adequate contact surfaces rather than making provision for wear.

The means and method function as follows: due to passage of the current, the portions of the electrodes adjacent to their contact surfaces, as indicated, for example, at 22 and 23, become incandescent because of the increased current density at these portions so that they heat the strip 7 by radiation from their inner faces and the segment 1 by contact therewith. The radiation from the portions 22, 23 which have become incandescent must be sufficiently intense for the foot of the strip 7 to attain the flow-temperature of the filler metal 9 substantially at the same time as the top of the segment, on which the strip 7 rests. Under these conditions, the molten filler metal forms spontaneously the concave meniscus 10, symmetrical with respect to the bisector of the angle between segment 1 and strip 7. This result can always be obtained by a judicious conformation of the graphite electrodes. It suffices in fact to choose an appropriate distance separating the sides of the strip 7 from the inner faces of the electrodes 2 and 3 (or 20 and 21), and to dimension the cross-sections of the electrodes in such a way that the current density therein attains the necessary values at the different points.

In other applications, the shape of the electrodes may be varied to suit the particular case, taking care that the radiating portions of the inner surfaces parallel to the element of low heat holding capacity are sufficiently large for heating this element to the required extent. The criterion of sufficient heating is the production of a smooth meniscus formed by the filler metal in the area of contact with the two elements to be joined, which must attain the flow-temperature of the filler metal substantially at the same time.

The invention may be applied to more complicated cases, for example, the butt welding or joining of a thin-walled tubular element with a tube with thick walls. In the case of tubes, there are advantageously provided a central electrode and an annular electrode, both in close contact with the thick-walled tube. The cylindrical surfaces of the electrodes radiate heat to the thin-walled tube, so as to present in cross-section approximately the same aspect as that of Fig. 1 or Fig. 2.

It is readily understood by those skilled in the art that it is possible to subdivide the two graphite electrodes into several individual electrodes.

While preferred embodiments of the invention have been illustrated and described, it will be understood that the invention is in no way limited to these embodiments and that many changes may be made within the spirit and scope of the invention as defined by the following claims.

What I claim and desire to secure by Letters Patent is:

1. A method for fusion bonding two different size workpieces in end-to-end relationship which comprises providing a first workpiece having a low heat content capacity and a second workpiece having a heat content capacity greater than the first workpiece, holding the workpieces in end-to-end and fixed relationship, positioning a piece of filler metal on the end of the second workpiece adjacent the contact area of the workpieces, the filler metal having a lower melting point than both the workpieces, applying a substantially localized electrical current adjacent the end of the second workpiece to be bonded to the first workpiece thereby to at least resistance heat said end of the second workpiece, applying radiation heat to the first workpiece in an area adjacent the end to be bonded to the second workpiece end, the electrical current and radiation heat being applied at a sufficient value and for a period of time sufficient to melt the filler metal thereby to join and fusion bond the workpieces.

2. A method for fusion bonding two different size workpieces in end-to-end relationship which comprises, providing a first workpiece having a relatively large surface area to thickness ratio and low heat holding capacity and a second workpiece having a lower surface area to thickness ratio and a heat holding capacity greater than the first workpiece, holding the workpieces in end-to-end and fixed relationship, positioning a piece of filler metal adjacent the contact area of the workpieces, the filler metal having a lower melting point than the two workpieces, applying a substantially localized electrical current adjacent the second workpiece end to be bonded thereby to resistance heat the end to be bonded, substantially simultaneously applying radiation heat to the first workpiece in an area adjacent the end to be bonded, the electrical current and radiation heat being applied at a sufficient value and for a period of time sufficient to melt the filler metal thereby to join and fusion bond the workpieces.

3. A method for fusion bonding two workpieces in end-to-end relationship which comprises; providing a first workpiece having a relatively large surface area to thickness ratio and low heat holding capacity and a second workpiece having a lower surface area to thickness ratio and a heat capacity greater than the first workpiece; clamping the second workpiece between two electrodes to provide electrical contact therewith and holding the two workpieces in a fixed end-to-end relationship, the electrodes having the characteristic of becoming incandescent and radiating heat from at least the end portions thereof when an electrical current of at least a certain value is applied thereto thereby to heat at least the end area of said first workpiece; disposing a piece of filler metal on said second workpiece adjacent the projected contact area of said workpieces; applying an electrical current to said electrodes for a period of time and of a sufficient value to heat the first workpiece by radiation only and to melt the welding metal and resistance heat the second workpiece at least adjacent the end area

thereby to butt join the workpieces and fusion bond them.

4. A method for joining two metal strips in end-to-end relationship by fusion bonding which comprises, providing a first metal strip having a relatively low heat content capacity and a second metal strip having a heat content capacity greater than the first strip, holding the metal strips in fixed end-to-end relationship, positioning a piece of filler metal on the end of the second strip adjacent the contact area of the strips, the filler metal having a lower melting point than both the metal strips, applying a substantially localized electrical current adjacent the second strip end to be joined to the first strip thereby to resistance heat said end, applying radiation heat to the first strip in an area adjacent the end to be joined to the second strip, the electrical current and radiation heat being applied at a sufficient value and for a period of time sufficient to melt the filler metal thereby, to join and fusion bond the metal strips.

5. A method according to claim 4, in which the metal strips are held with their corresponding sides in substantially parallel planes and said filler metal is disposed contacting said first strip with the radiation heat being applied to the sides of said first strip.

6. A commutator segment with a strip conductor connected end-to-end thereto for rotary electrical machinery manufacture by the method which comprises, providing a first electrically conductive workpiece having a low heat content capacity and a second conductive workpiece having a heat content capacity greater than the first workpiece, disposing the workpieces in end-to-end fixed relationship, positioning a piece of filler metal on the second workpiece adjacent the contact area of the workpieces, the filler metal having a lower melting point than the two workpieces, applying a substantially localized electrical current adjacent the second workpiece end to be bonded thereby to at least resistance heat the end to be bonded, substantially simultaneously applying radiation heat to the first workpiece in an area adjacent the end to be bonded, the electrical current and radiation heat being applied at a sufficient value and for a period of time sufficient to melt the filler metal thereby, to fusion bond the workpieces.

7. A commutator segment with a strip conductor connected end-to-end thereto for rotary electrical machinery manufactured by the method which comprises, providing a first electrically conductive metallic strip having a relatively low heat content capacity and a second conductive metallic strip having a heat content capacity greater than the first strip, holding the metallic strips in fixed end-to-end relationship, positioning a piece of filler metal on one of the strips adjacent the contact area of the strips, the filler metal having a lower melting point than both the metallic strips, applying a substantially localized electrical current adjacent the end of the second strip to be joined to the first strip thereby to resistance heat the end to be joined, substantially simultaneously applying radiation heat to the first strip in at least an area adjacent the end to be joined to the second strip, the electrical current and radiation heat being applied at a sufficient value and for a period of time sufficient to melt the filler metal thereby to join and fusion bond the metallic strips.

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