

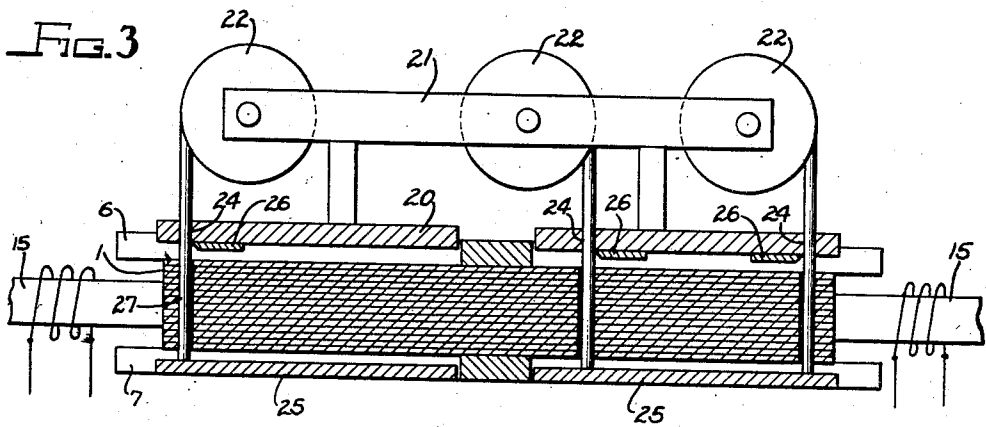
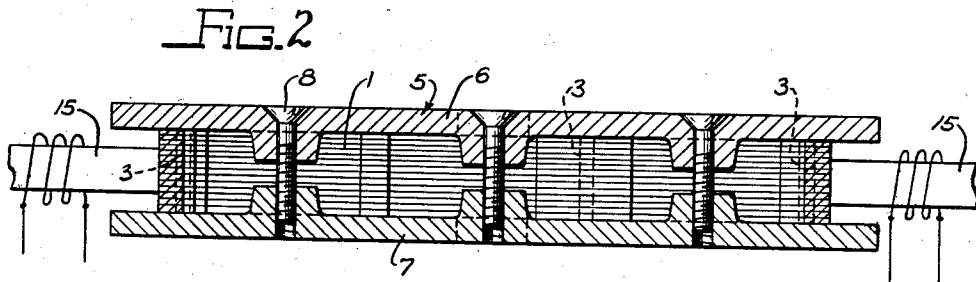
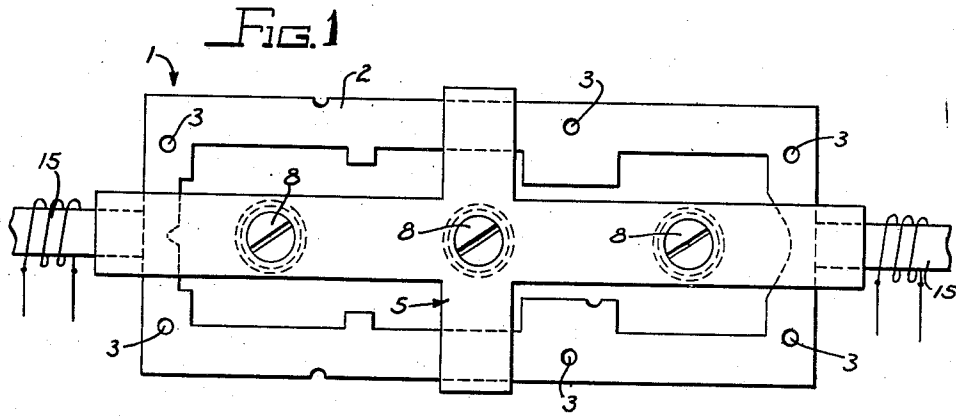
March 22, 1955

H. EPSTEIN
METHOD OF RIVETING

2,704,801

Filed April 3, 1950

2 Sheets-Sheet 1



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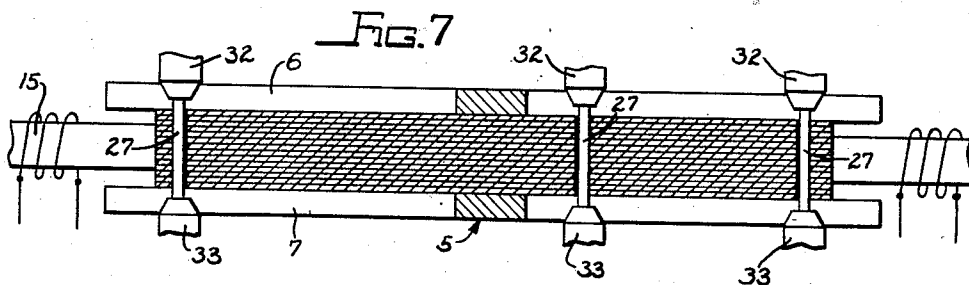
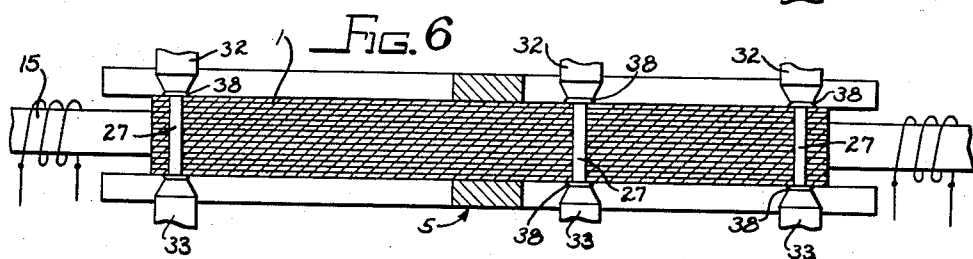
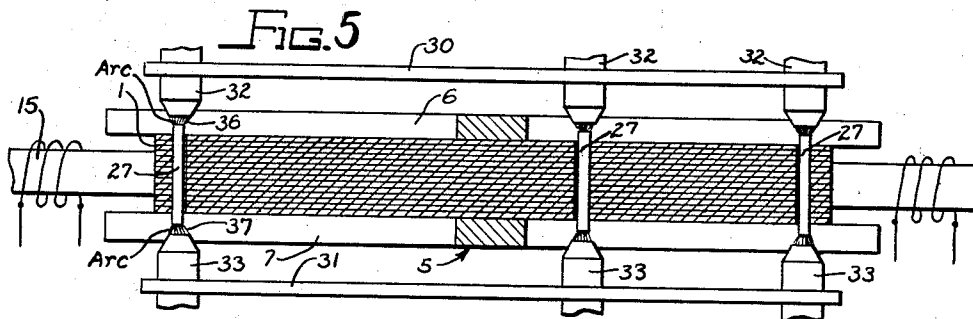
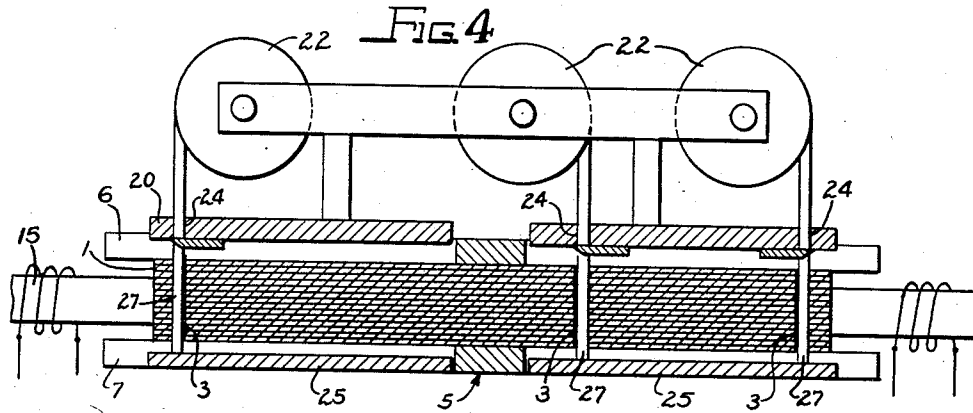
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H. EPSTEIN
METHOD OF RIVETING

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2 Sheets-Sheet 2



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METHOD OF RIVETING

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6 Claims. (Cl. 219—2)

This invention relates to the art of riveting and, more particularly, to a method of riveting together laminations, particularly of an electrical apparatus such as, for instance, the laminations of an electromagnetic core structure.

In a laminated electromagnetic core, such as the core for a transformer or a reactor, it is customary to stack the laminations together and then to secure the laminations together by a number of rivets that are passed through aligned rivet-receiving holes in the laminations of the stack. These are preformed rivets that are inserted, one at a time, through the respective rivet holes and then riveted over. It is one of the objects of the present invention to provide a method of riveting whereby wire from a reel is advanced into the respective rivet holes, then cut off to size, and then the cut length of wire within the rivet hole is converted into a rivet by heat and pressure. It is a further object of the present invention to provide a method of riveting transformer cores wherein a wire is fed in a step by step manner into transformers to be riveted, cut to length, and then the cut lengths are heated and riveted over.

In accordance with the preferred embodiment of the present invention the lengths of wire that are to be converted into rivets are cut to size so that the ends of the wire project short distances beyond the stack of laminations to be riveted. Thereafter the wires are heated in such a manner that only the ends of the wire become very hot, sufficient to be deformed into rivet heads, whereas the intermediate portion of the wire is heated only to an intermediate temperature. By this arrangement advantage is taken of the natural expansion of the intermediate portion of the wire, due to heat, for subsequently drawing the riveted stack of laminations together upon cooling of the rivet as is usual in riveting with preheated rivets, and at the same time the applicant avoids the distortion of the intermediate portion of the rivet during the operation. In accordance with the preferred embodiment of the present invention the ends of the rivet are heated by drawing an electric arc at each end of the wire. The arcing current produces an intense heat at the end of the wire, which heat is sufficient to soften or even to melt the end of the wire. There is current conduction from one end of the wire to the other which produces heating of the intermediate portion of the wire in an amount sufficient to cause the desired expansion of the wire while at the same time avoiding such heating as would soften the wire. After the ends of the wire have been heated by the electric arcs formed at the ends thereof the softened ends of the wire are hammered or swaged to form rivet heads.

In the preferred embodiment of the present invention the assembled stack of laminations are held in a clamp or fixture which clamps the laminations together the desired amount preparatory to riveting. Thereafter lengths of iron wire which are to constitute the rivets are threaded through the respective rivet holes in the assembled stack of laminations and cut to size. A strong magnetic field is then set up through the stack of laminations which field causes the passage of magnetic flux through the rivet holes and thus produces a magnetic holding of the wires in the rivet holes. The wires are thus held in place magnetically during subsequent operations of heating the ends of the wires and forming the wire ends into rivet heads.

While in the preferred embodiment of the present invention it is contemplated that the ends of the wires are heated to a very high temperature by electric arcs, it is within the purview of the present invention to use resistance heating for the ends of the wire. If a pair of electrodes are placed in electric contact with the ends of the wire rivets and then an electric current passed

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therethrough, there will be a concentration of heat at the ends of the wires for two reasons. One reason for the heat concentration lies in the fact that there is a contact resistance between the electrode and the end of the wire.

Another reason for the heat concentration of the ends of the wire is due to the fact that the intermediate portions of the wire are being cooled by heat conduction from the intermediate portions of the wire to the adjacent laminations in contact therewith while the protruded ends are not thus cooled. This reduces the resistance of the intermediate portion of the wire, thereby reducing the amount of heat that is produced in that portion of the wire, namely, that portion which is within the core. An appreciable portion of this reduced amount of heat is extracted by conduction from the wire to the adjacent core structure.

The attainment of the above and further objects of the present invention will be apparent from the following specification taken in conjunction with the accompanying drawings forming a part thereof.

In the drawings:

Figure 1 is a plan view showing a stack of laminations clamped in a fixture for carrying out the present process;

Figure 2 is a partial longitudinal sectional view of Figure 1;

Figure 3 is a side view illustrating, diagrammatically, the position of the wire reels for insertion of the wire ends into the transformer cores;

Figure 4 is a view similar to Figure 3 illustrating the cutting of the rivet wires;

Figure 5 shows the core structure in position between the electrodes;

Figure 6 shows the step of swaging the ends of the wires; and

Figure 7 is a view corresponding to Figure 5 and showing an arrangement wherein the rivet wires are heated by contact with the electrodes.

Reference may now be had more particularly to the drawings wherein like reference numerals designate like parts throughout.

In Figures 1 and 2 there is shown a magnetic transformer core 1 consisting of a stack of rectangular laminations 2, of a conventional shape, each of said laminations having rivet-receiving holes 3. In this instance there are six such holes. The laminations 2 are stacked one on top of another, with corresponding rivet holes in alignment, to form a core of the desired thickness. The assembly is then clamped in a fixture 5, which may be of any desired construction and is here shown as consisting of similar upper and lower cross-shaped bars 6 and 7 clamped together by screws 8 to hold the stack at the proper compression and to permit carrying of the stack of laminations as a unit in performing the present process. The clamped core is then placed on a table between two electromagnets 15—15. The magnets are brought into contact with the core so that when they are energized they create a strong magnetic field through the core. The machine is provided with an arm 20 that includes a frame 21 integral therewith on which are mounted a number of reels 22 of rivet wire. Three such reels may be provided, one for each of the holes 3 on one side of the core, or there may be six such reels, one for each of the six rivet holes 3 in the transformer core. In the drawing the reels 22 are shown, diagrammatically, much smaller than their actual sizes, to facilitate illustration thereof. The arm 20 has a corresponding number of wire-receiving holes 24 therethrough through which the ends of the wires from the respective reels extend, the holes 24 being spaced identically with the spacing of the holes 3 in the laminations of the transformer core. A wire-cutting apparatus 26 is mounted on the arm 20 under each hole 24, each cutting apparatus consisting of an ordinary shears or wire clipper. The arm 20 with the wire reels thereon is rotated into position to bring the holes 24 thereof immediately over the corresponding holes in the transformer core. Thereafter each one of the reels 22 is turned, in any desired manner, to advance the end of the wire thereon through the corresponding hole 3 in the stack of laminations, until the wire comes in contact with a stop or stops 25 below the core. Thereafter, the cutting shears are operated to cut the ends of

the wires. This leaves a wire in each one of the holes 3 with the ends of the wire extending outwardly above and below the core the desired amount. The magnets 15—15 are then energized. The wire used is an iron wire which is affected by the strong magnetic field that permeates the core, and the cut lengths of wire 27 are thereby magnetically held in place. Thereafter the arm 20 that carries the reels 22 is swung out of place and the bottom wire stop 25 is moved out of place.

Upper and lower electrode-carrying arms 30—31 are then swung into place. The arm 30 has electrodes 32 thereon over the respective wires 27, and the arm 31 has corresponding electrodes 33 thereon. The electrodes 32—33 of the two arms are spaced so that there is one upper electrode and one lower electrode opposite each wire 27 that extends through the holes 3 in the core. Thereafter arcs 36—37 are struck between opposite ends of each wire 27 to the adjacent electrodes 32—33, the electric circuit extending from each electrode 32, through the corresponding arc 36 and wire 27, thence through the arc 37 to the corresponding electrode 33. The electric current that flows through each wire 27 produces a certain heating of the wire with a corresponding expansion thereof. At the same time the arcs 36—37 produce enormously greater heating of the ends of the wire 27 so that the end of each wire becomes very soft while the rest of the wire, although heated, is still rigid. Thereafter the electrode-carrying arms 30—31 are moved towards one another thereby forcing the electrodes 32—33 into contact with the softened ends of the wires and causing the electrodes to act as pressure hammers to swage the softened ends of the wires 27 and rivet them over to form rivet heads 38. During this swaging operation the electric current through the electrodes 32—33 may be turned off. After the swaging operation the electrode-carrying arms 30—31 are swung out of place and the current through the electromagnets is turned off. The previously heated rivet wires 27 cool and draw the swaged over rivet heads 38 together, as is usual in the action of rivets.

In Figure 7 there is illustrated an arrangement similar to that of Figure 5 but differing therefrom only in that the step of drawing the arcs 36—37 is omitted. In carrying out the method in accordance with the modification illustrated in Figure 7 the electrodes 32—33 are brought into contact with the cut wires 27, following the steps previously explained in connection with Figures 1 through 4, and thereafter an electric current is passed from one electrode 32 to the opposite electrode 33 through the corresponding wire 27. The contact between the electrodes 32—33 and the corresponding ends of the rivet wires 27 is a rather light and poor contact. There is considerable electrical resistance at the place of contact between the ends of the wire 27 and the electrodes 32—33 so that there is excessive heating at the ends of the wire merely due to the I²R loss at the ends of the wire. The wire itself has a sufficient coat of oxide thereon and the edges of the holes 3 in the laminations 2 have a sufficient coat of oxide thereon so that practically all of the current between each pair of electrodes passes through the wire and is not by-passed to flow through the core. As a result the length of wire 27 between the electrodes is also heated to produce expansion thereof. The length of wire within the core is constantly cooled by contact with the core, which is a good heat conductor. As a result that portion of the rivet wire does not become excessively hot. Its electrical resistance is therefore less than that of the ends of the wires so that the heat produced is thus further concentrated at the ends of the wires. After the ends of the wire have become sufficiently hot the electrode-carrying arms 30—31 are forced together, thereby causing the electrodes to act as hammers to swage the softened ends of the wires 27 to form rivet heads, the same as in Figure 6.

In describing the above process it has been assumed that all the rivets along one or both edges of the core are formed at the same time. Course, each rivet may be individually formed so that the six rivets are formed successively. The various mechanical operations may be carried out manually or by suitable automatic mechanisms.

In compliance with the requirements of the patent statutes I have here shown and described preferred embodiments of my invention. It is, however, to be understood that the precise embodiments hereinabove described

are merely illustrative of the principles of the invention and not by way of limitation.

What I consider new and desire to secure by Letters Patent is:

1. The method of riveting a number of members together which comprises inserting a headless, magnetic wire through respective openings in the members with the end of the wire projecting beyond the members, said wire being of a size to pass through said openings throughout its entire length, holding the wire in place within said openings by applying a magnetic field to said members so as to secure said wire to the walls defining said openings, heating the extended end of the wire by bringing an electrode adjacent the end of the wire and passing an electric current therebetween, and then forming the heated end of the wire into a rivet head.

2. The method of riveting together a stack of laminations of an electromagnetic core which comprises, clamping the laminations together, inserting a wire through aligned perforations in the laminations of the core with the ends of the wire projecting beyond the core, holding the wire in place by setting up a magnetic field through the wire, placing electrodes adjacent to the ends of the wire and heating the ends of the wire by passing an electric current therethrough from electrode to electrode through the wire, then swaging the heated ends of the wire by moving the electrodes towards one another against the ends of the wire.

3. The method of riveting together a plurality of members having aligned rivet receiving holes therein which comprises inserting a magnetic rivet wire through the holes with the opposite ends of the wire projecting beyond the members, holding the wire in place by setting up a magnetic field through the wire, heating the extended ends of the wire, and then riveting over the heated wire ends.

4. The method of riveting together a plurality of members having aligned rivet receiving holes therein which comprises inserting a magnetic rivet wire through the holes with the opposite ends of the wire projecting beyond the members, holding the wire in place by setting up a magnetic field through the wire and heating the extended ends of the wire by forming electric arcs at the extended ends of the wire, and then riveting over the heated wire ends.

5. The method of riveting a number of members together which comprises inserting a wire through the members with the end of the wire projecting beyond the members, holding the wire in place by passing a magnetic field therethrough, heating the extended end of the wire by striking an electric arc with that end of the wire, and then forming the heated end of the wire into a rivet head.

6. The method of riveting a stack of transformer laminations together which comprises providing the stack of laminations with aligned rivet receiving holes, clamping the stack of laminations in a fixture, threading headless rivet wire of a smaller diameter than the rivet holes throughout its entire length through the aligned rivet holes, setting up a magnetic field through the laminations for holding the rivet wires in position in said rivet holes and then while the laminations are still maintained clamped in said fixture, bringing a pair of electrodes into current conducting relation with the ends of each wire, passing an electric current from electrode to electrode through the rivet wire between them and then forcing the electrodes into pressure engagement with the wire to form rivet heads at the ends of the wire.

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